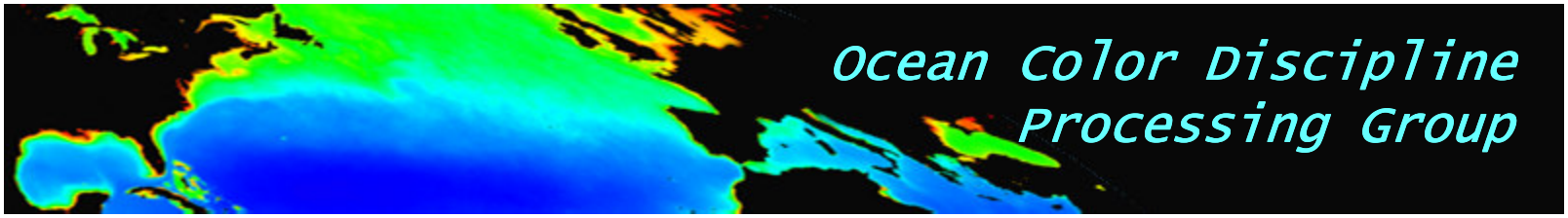



# MODIS/Aqua Quality Assessment

Bryan Franz

*SAIC*

Ocean Color Discipline Processing Group

# MODIS/Aqua Calibration and Algorithm Testing

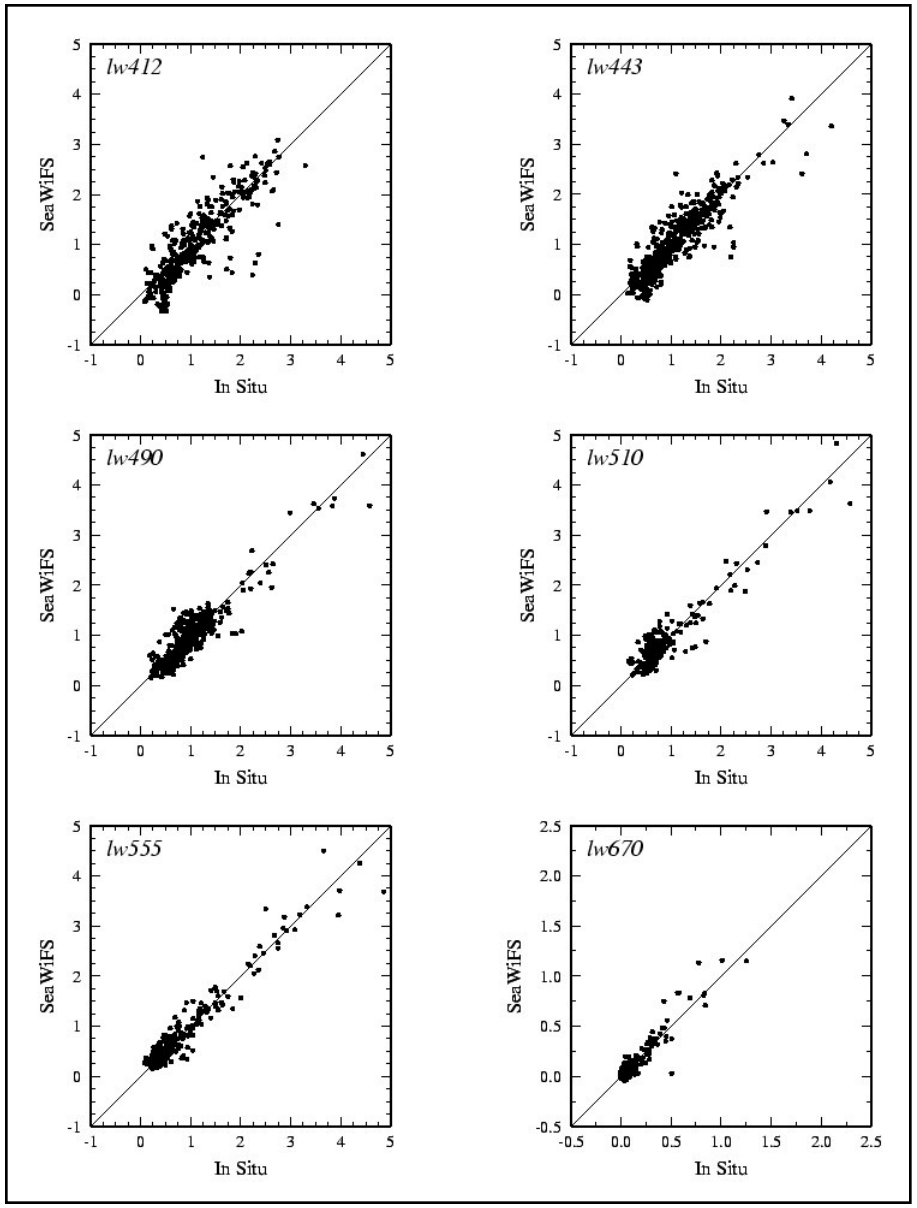
- Perform independent evaluation of each potential change in calibration or processing algorithms
  - relative to previous configuration
  - relative to *in situ*
  - relative to SeaWiFS

- For each potential change:
  - recompute vicarious calibration (one gain per band for all time)
  - re-evaluate *in situ* match-ups
  - evaluate temporal trends over entire mission
    - process first 4-days of each 32-day period
    - reduce to common bins with SeaWiFS
    - compare global and regional averages over time
  - complete evaluation in approximately 2 days

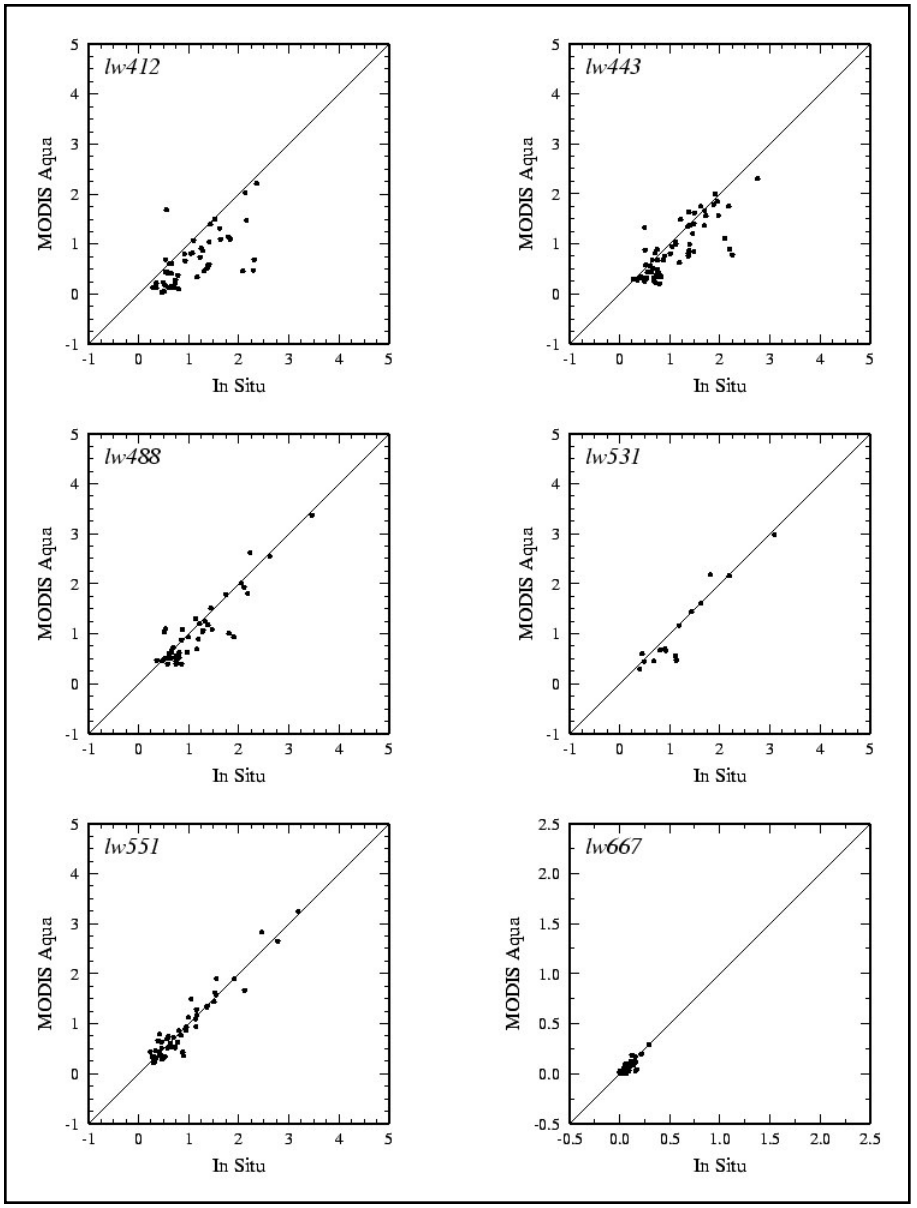
# Aqua Calibration and Algorithm Test Sequence

- AT01: Fresnel BRDF, no polarization correction, log-fitted L1B LUT
- AT02: AT01 with standard polarization correction
- AT03: AT01 with corrected phase polarization correction
- AT04: AT03 with Gothic-R BRDF
- AT05: AT03 with Gothic-R + f/Q BRDF
- AT06: AT01 with corrected phase and magnitude polarization correction
- AT07: AT06 with HIGLINT masking
- AT08: AT07 with reduced cloud threshold (0.027)
- AT09: AT06 with reversed polarizer rotation
- AT10: AT07 with reduced cloud threshold (0.022)
- **AT11: AT08 with updated L1B LUT (V4.3.1.5S)**
- AT12: AT11 with Fresnel + f/Q BRDF
- AT13: AT15 with alternate L1B LUT (piece-wise polynomial fit)
- AT14: AT11 with modified polarization (NIR from Terra)
- AT15: AT11 with updated vicarious calibration

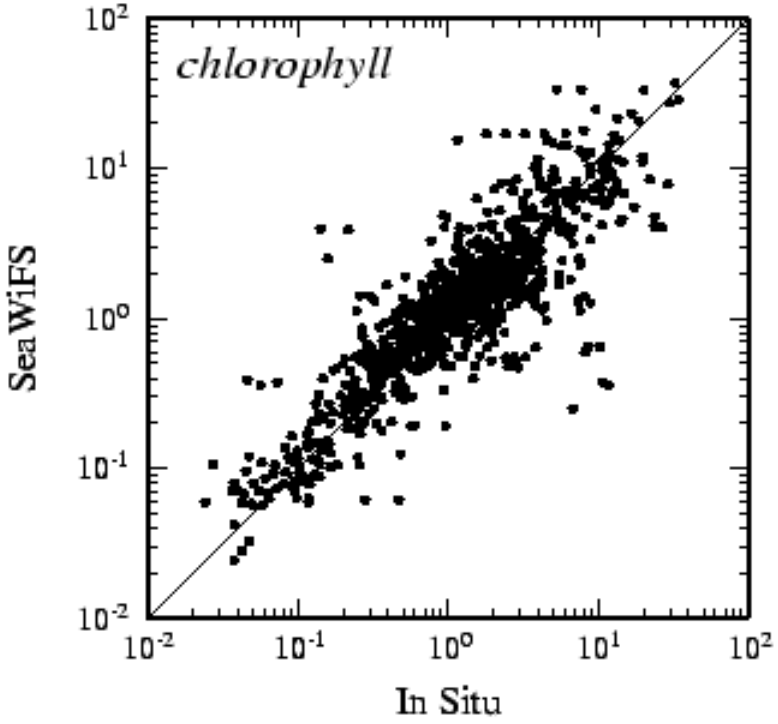
# SeaWiFS Lw
# OCDPS R4



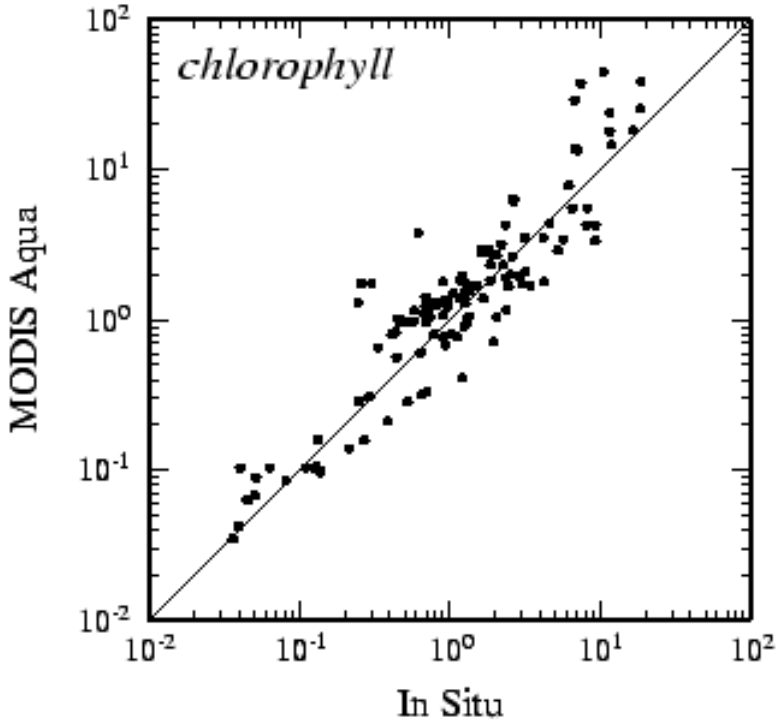

# MODIS/Aqua Lw
# OCDPS R0



**SeaWiFS**
**OCDPS R4**
**OC4 Chlorophyll**



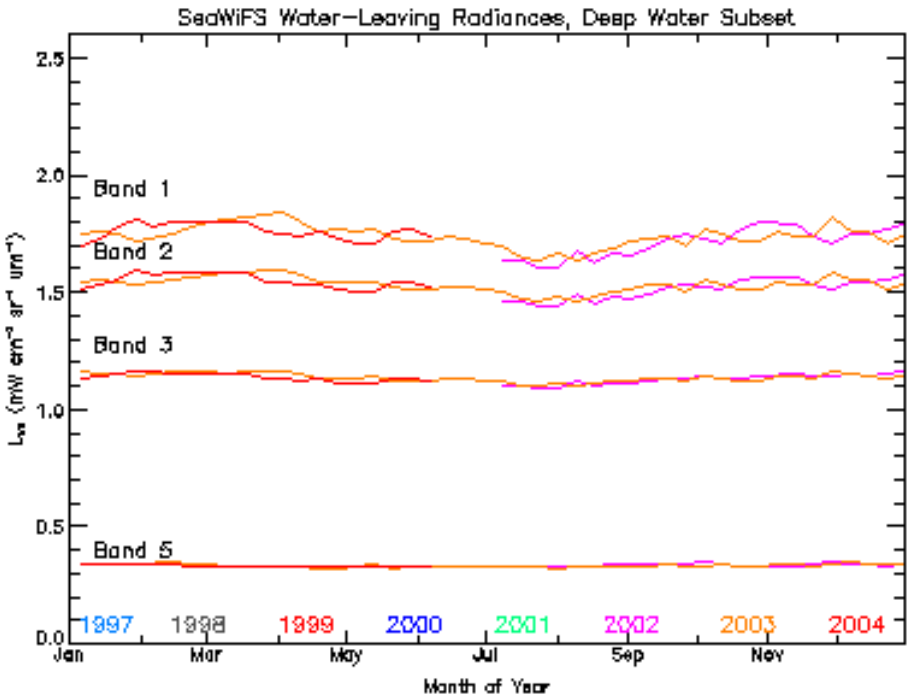

**MODIS/Aqua**
**OCDPS R0**
**OC3 Chlorophyll**



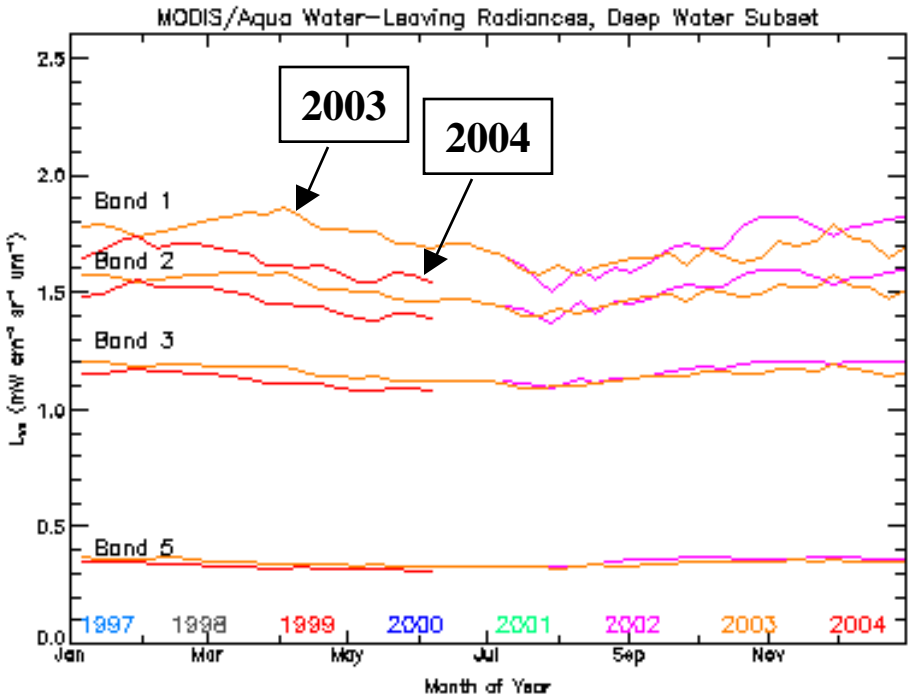
# Annual Repeatability in nLw

## Deep-Water Subset, 8-Day Bins

### SeaWiFS R4



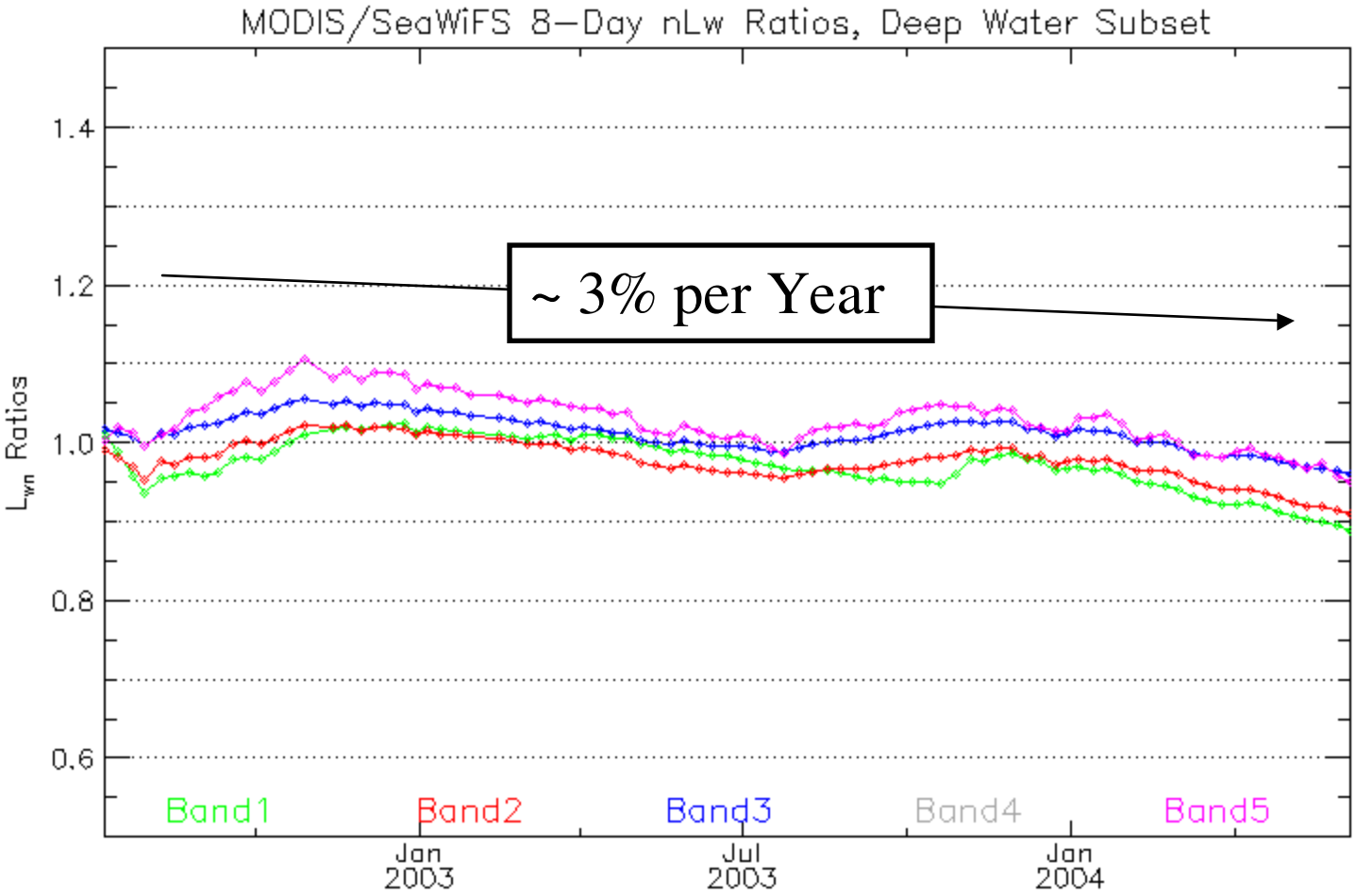

### MODIS/Aqua R0




Temporal stability of MODIS/Aqua still not demonstrated.

# nLw: MODIS/Aqua vs SeaWiFS

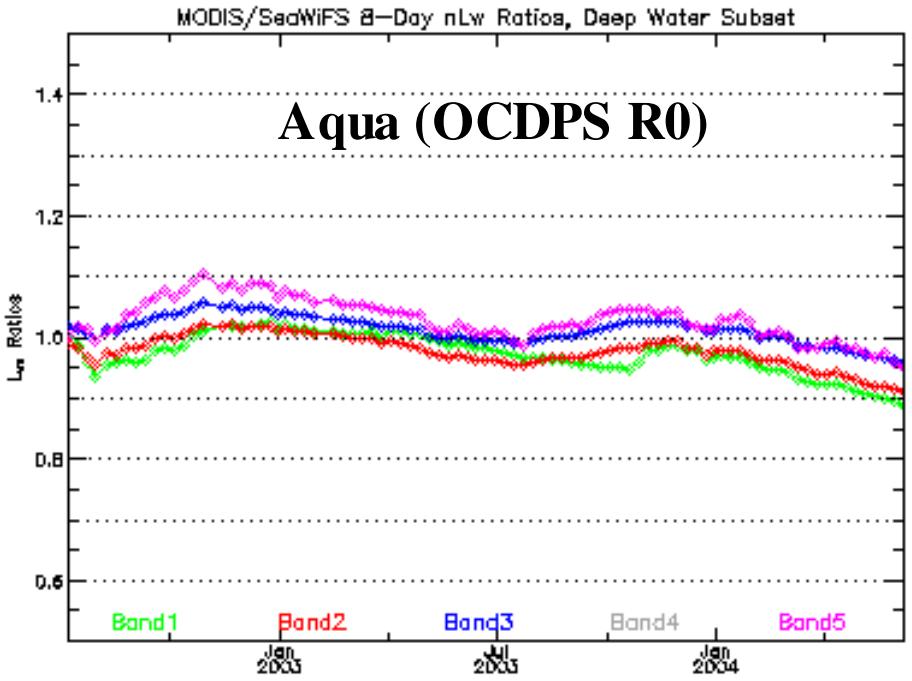
## Deep-Water

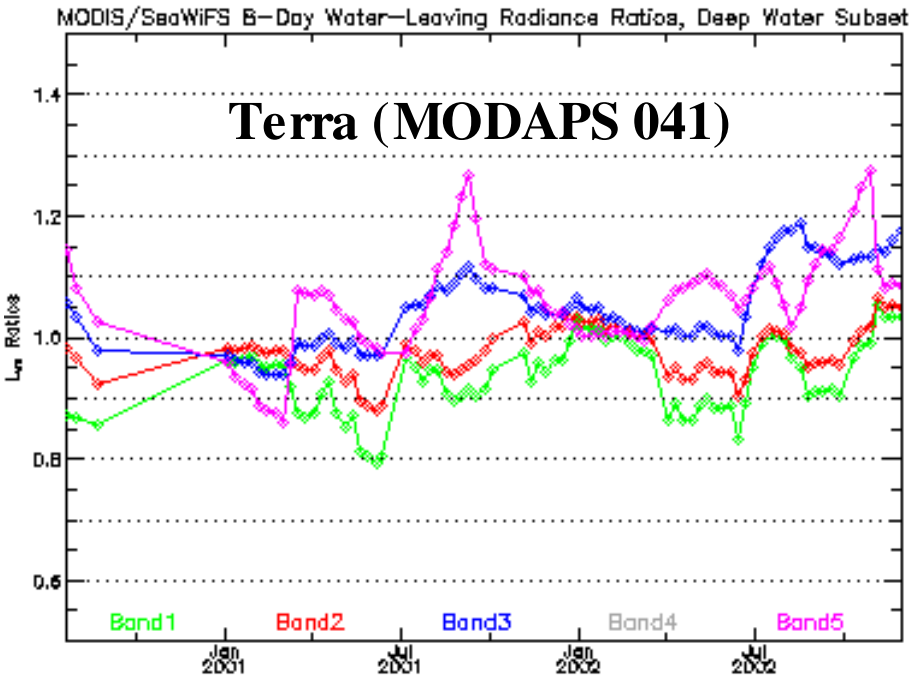



MODIS/Aqua water-leaving radiances show long-term decay relative to SeaWiFS, in addition to a seasonal cycle.

# nLw: MODIS/SeaWiFS Ratio Trends

## Deep-Water

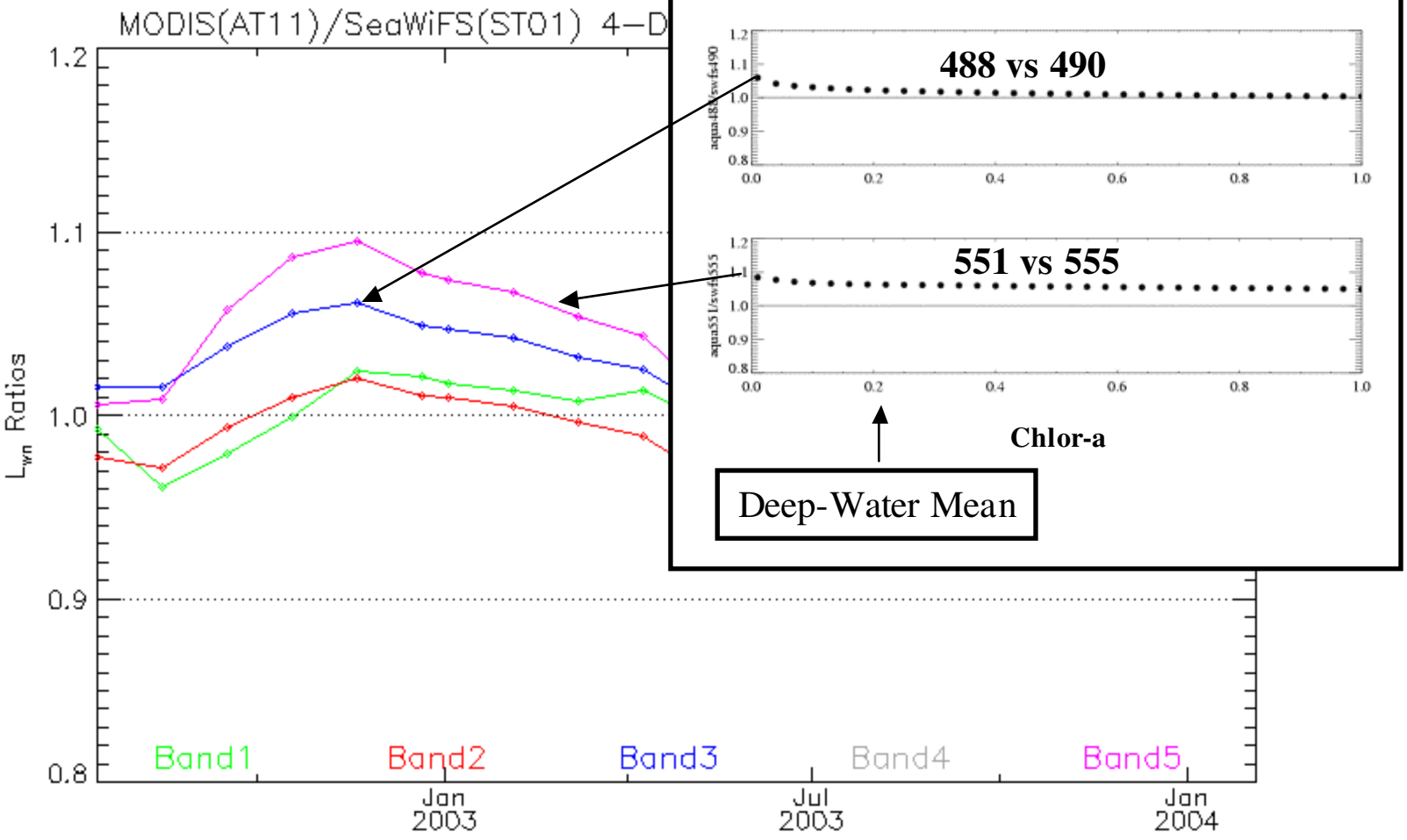



Aqua shows much better short-term stability than MODIS/Terra.

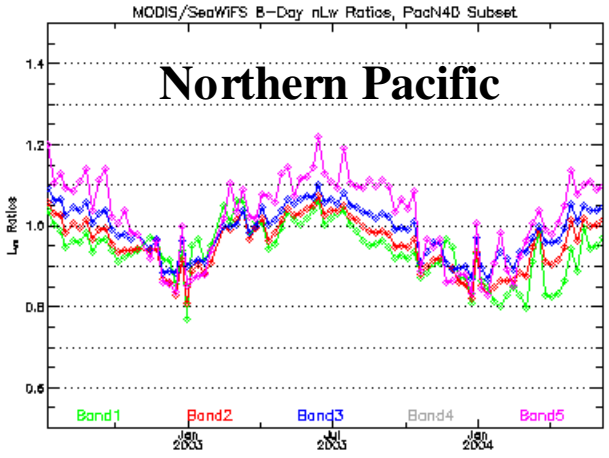
# nLw: MODIS/Aq[illegible] vs SeaWiFS

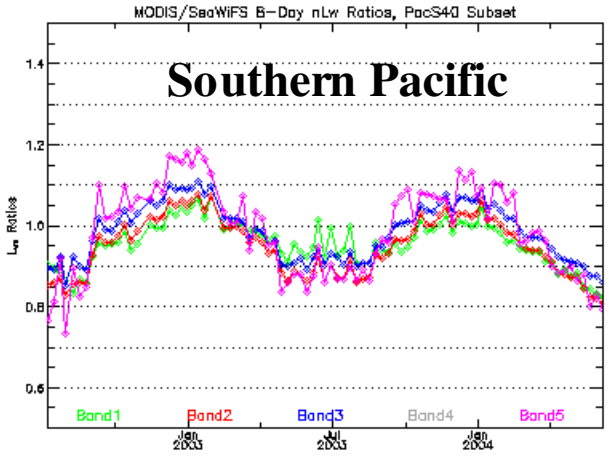
## Deep-W[illegible]

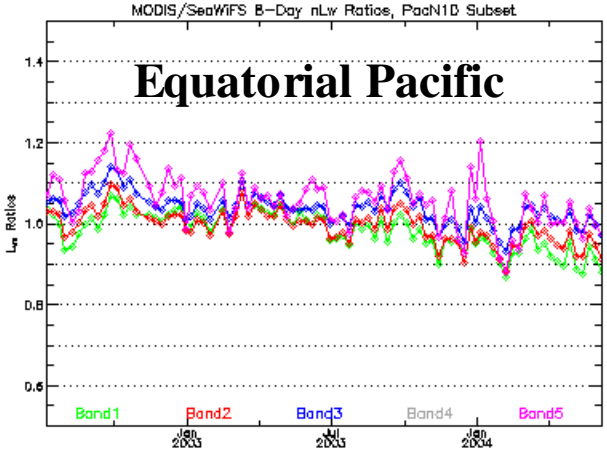



Bifurcation makes sense. Relative to SeaWiFS, the 488 and 551 bands should be elevated at chlorophylls typical of deep water (~0.2 mg/m$^3$).

# nLw: MODIS/Aqua vs SeaWiFS



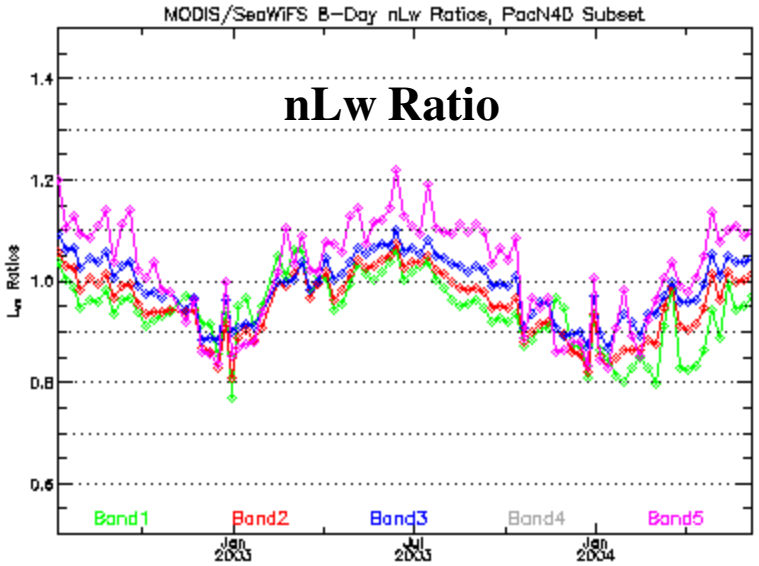



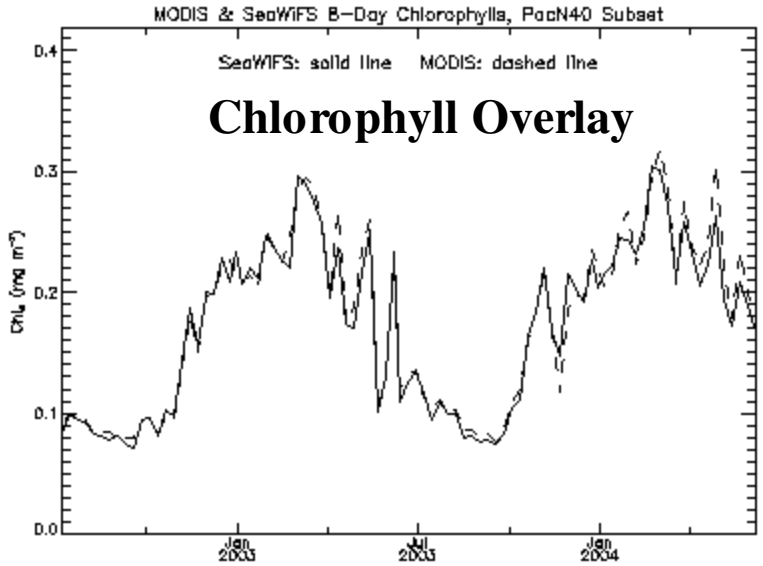




Seasonal differences of +/- 10% between SeaWiFS and MODIS/Aqua still evident at high latitudes (high solar zenith). After polarization correction, behavior is spectrally consistent, but cause is unknown.

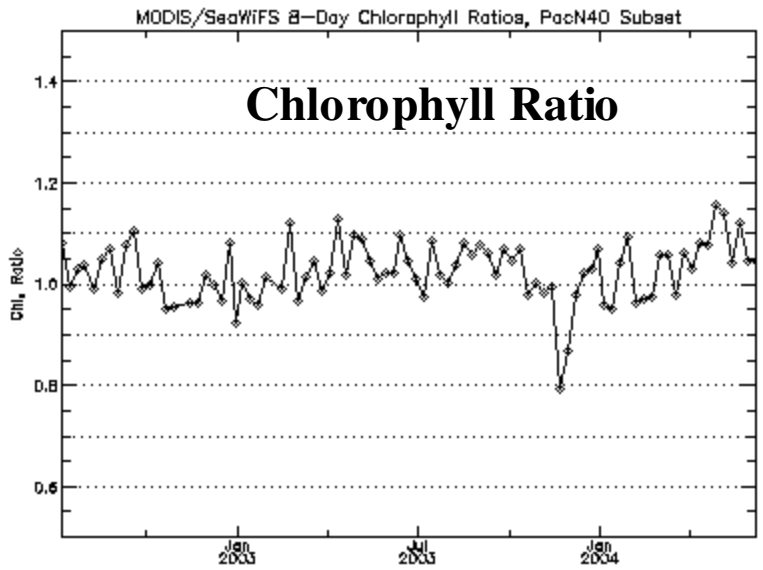
# MODIS/Aqua vs SeaWiFS

## Northern Pacific



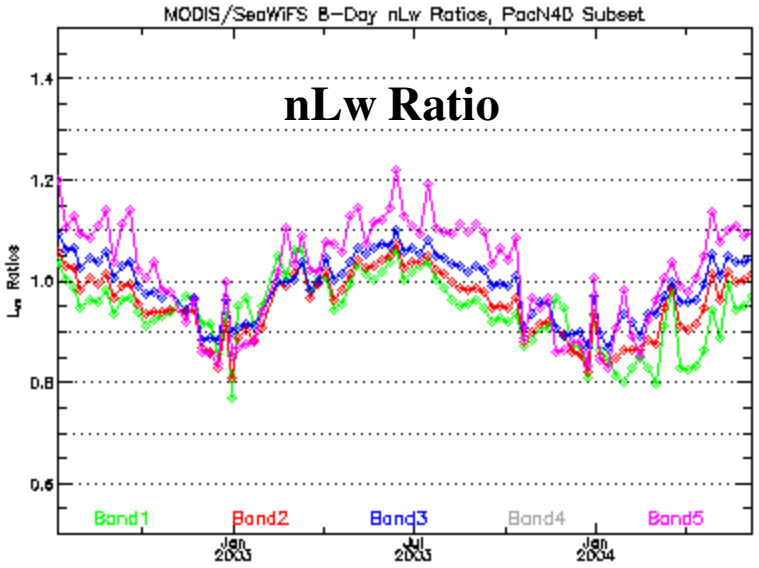



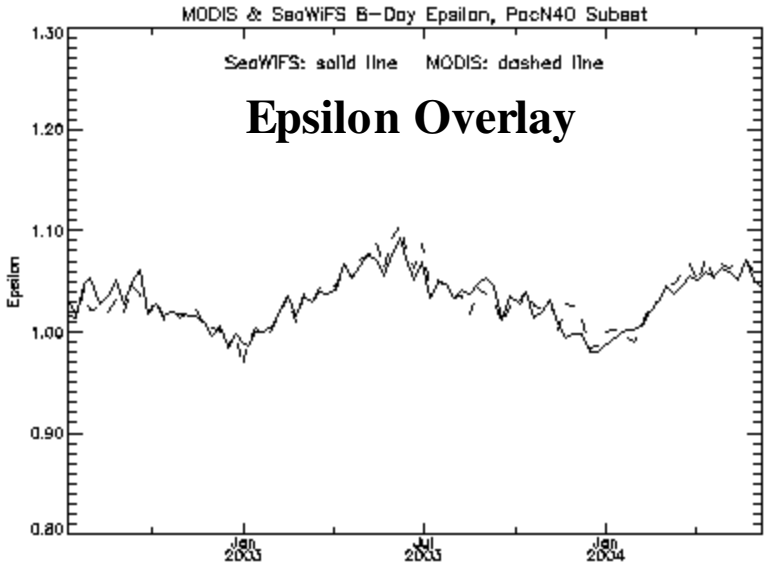

Chlorophyll agreement is very good. Rrs band ratios do not show seasonal cycle relative to SeaWiFS.



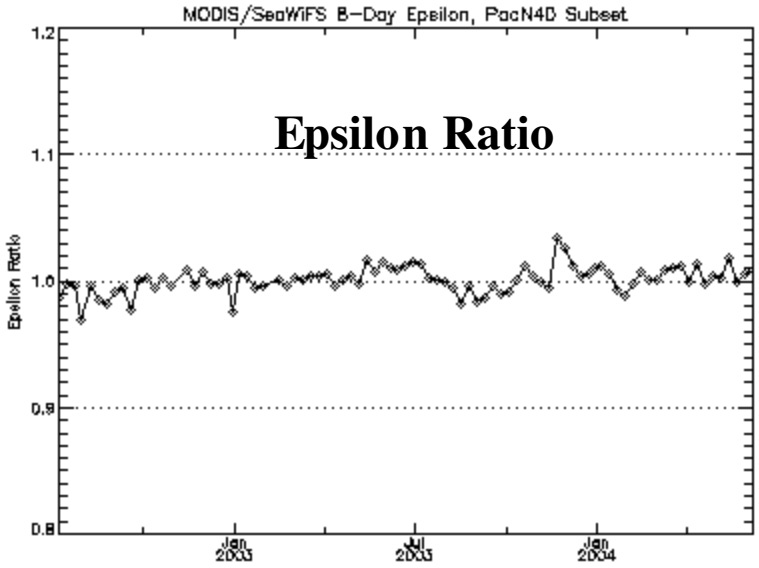
# MODIS/Aqua vs SeaWiFS

## Northern Pacific



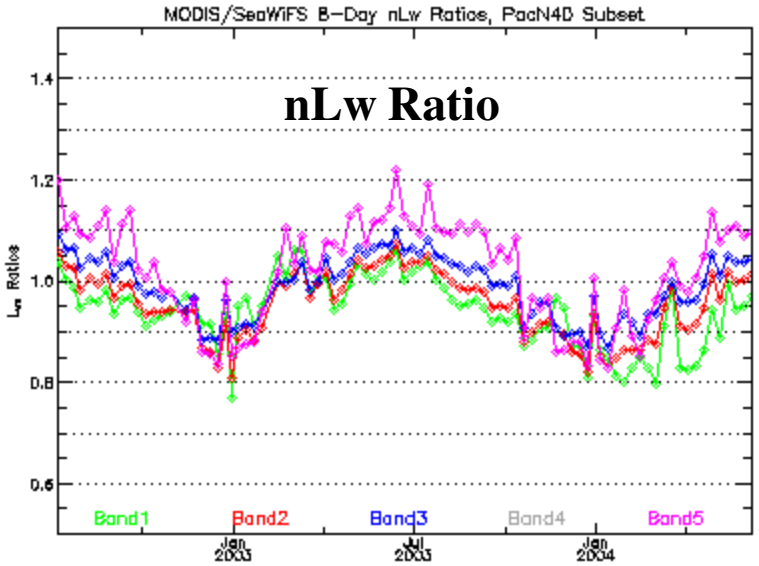



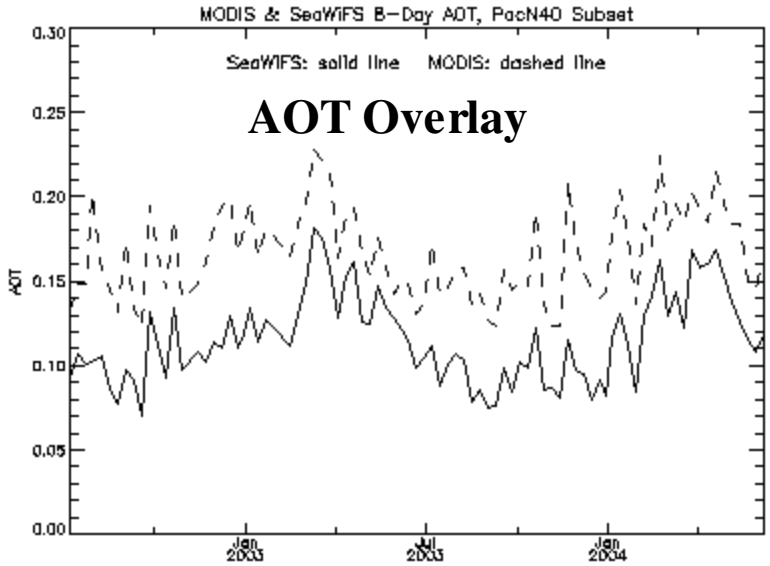

Epsilon agreement is very good. NIR band ratios do not show seasonal cycle relative to SeaWiFS.



# MODIS/Aqua vs SeaWiFS

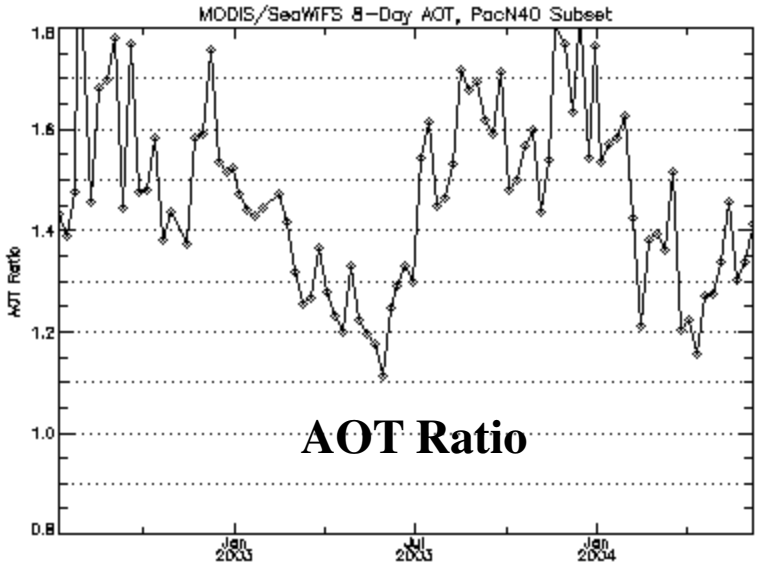
## Northern Pacific




AOT does show seasonal cycle relative to SeaWiFS. AOT is also higher for MODIS.

Excess signal at 869nm? OOB?



# RVS and Striping

# Causes of RVS

- Change in mirror reflectivity per AOI
- Change in mirror polarization sensitivity with AOI
- Systematic error in atmospheric correction with viewing angle
- Uncorrected surface BRDF

# Causes of Striping

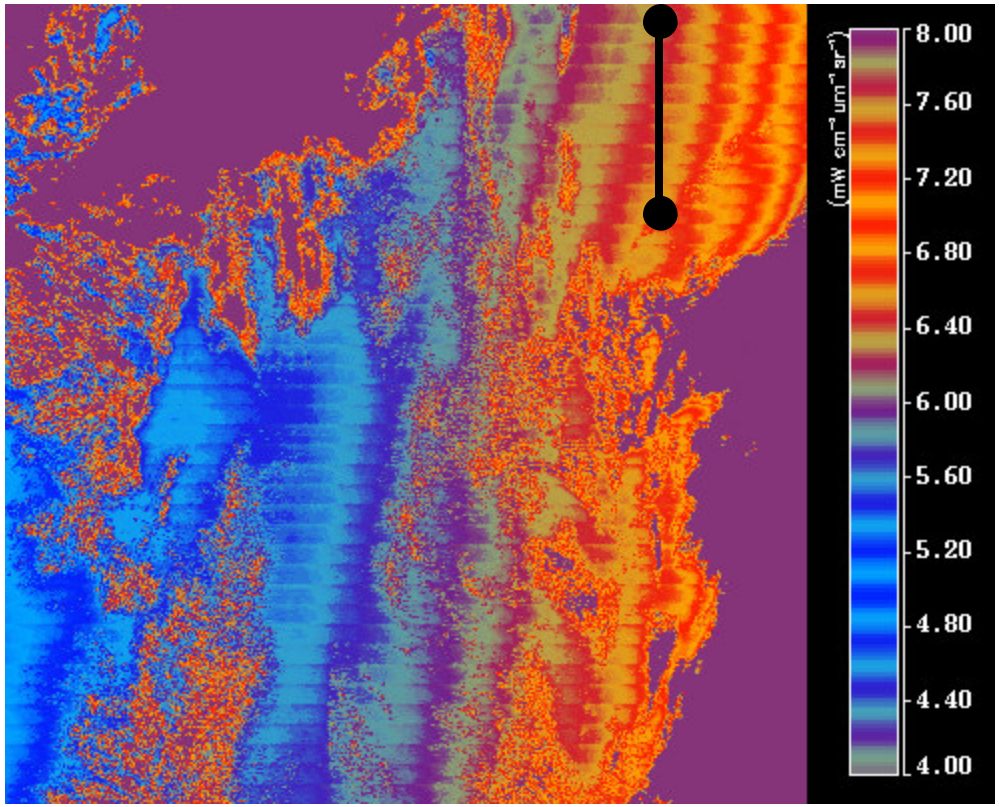
- Detector gain differences (may include non-linearity)
- Detector RSR differences
  - effects will vary with source spectral shape
- Slight differences in mirror AOI per detector
  - reflectivity of mirror per side, per AOI
  - polarization sensitivity per side, per AOI
- Error in geometry dependence of atmospheric correction model

# Causes of Banding

- Change in mirror reflectivity per side
- Side-specific RVS, polarization sensitivity differences

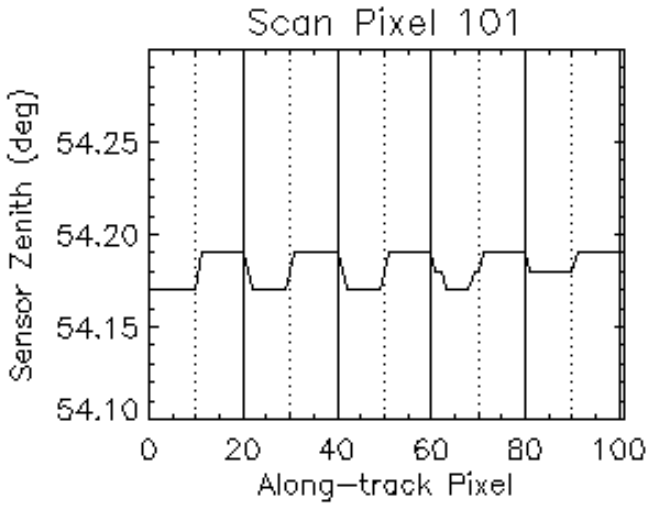
# MODIS/Aqua TOA Radiance

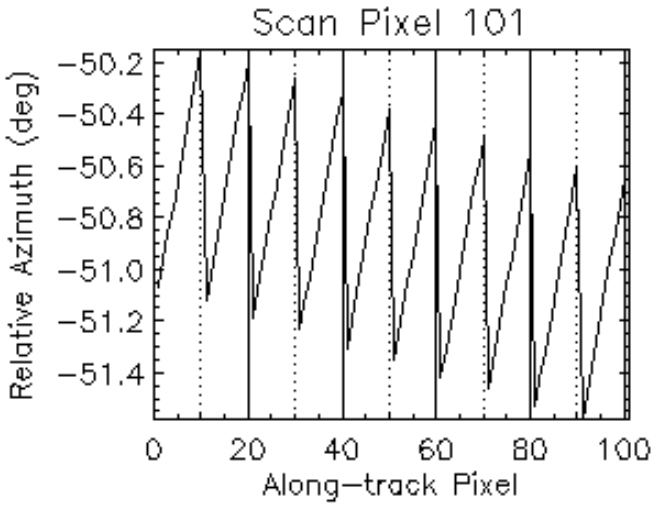
412 nm, Eastern Scan Edge

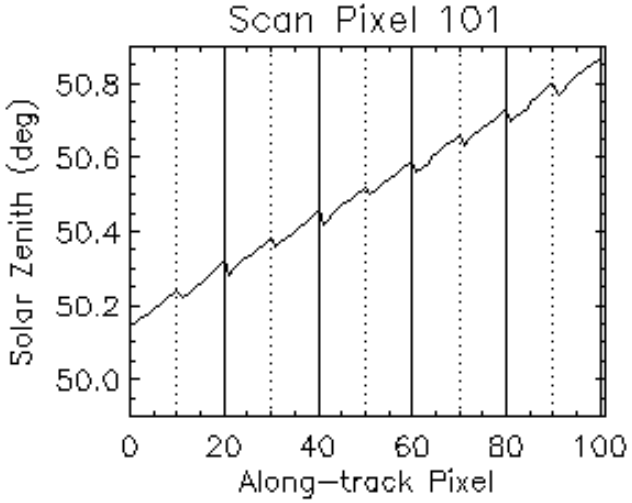


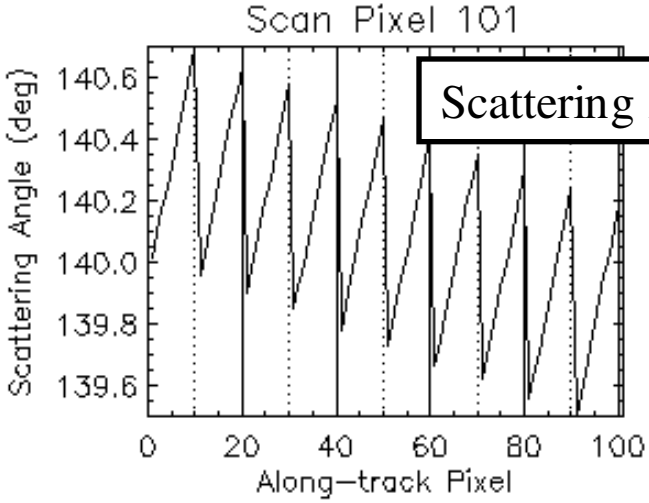

Striping is visible in TOA radiances, but some of this striping is expected: due to variation in viewing geometry per detector which results in a variation in observed atmospheric signal.

# MODIS/Aqua
# Variation of Geometry Along-Track
## Eastern Scan Edge



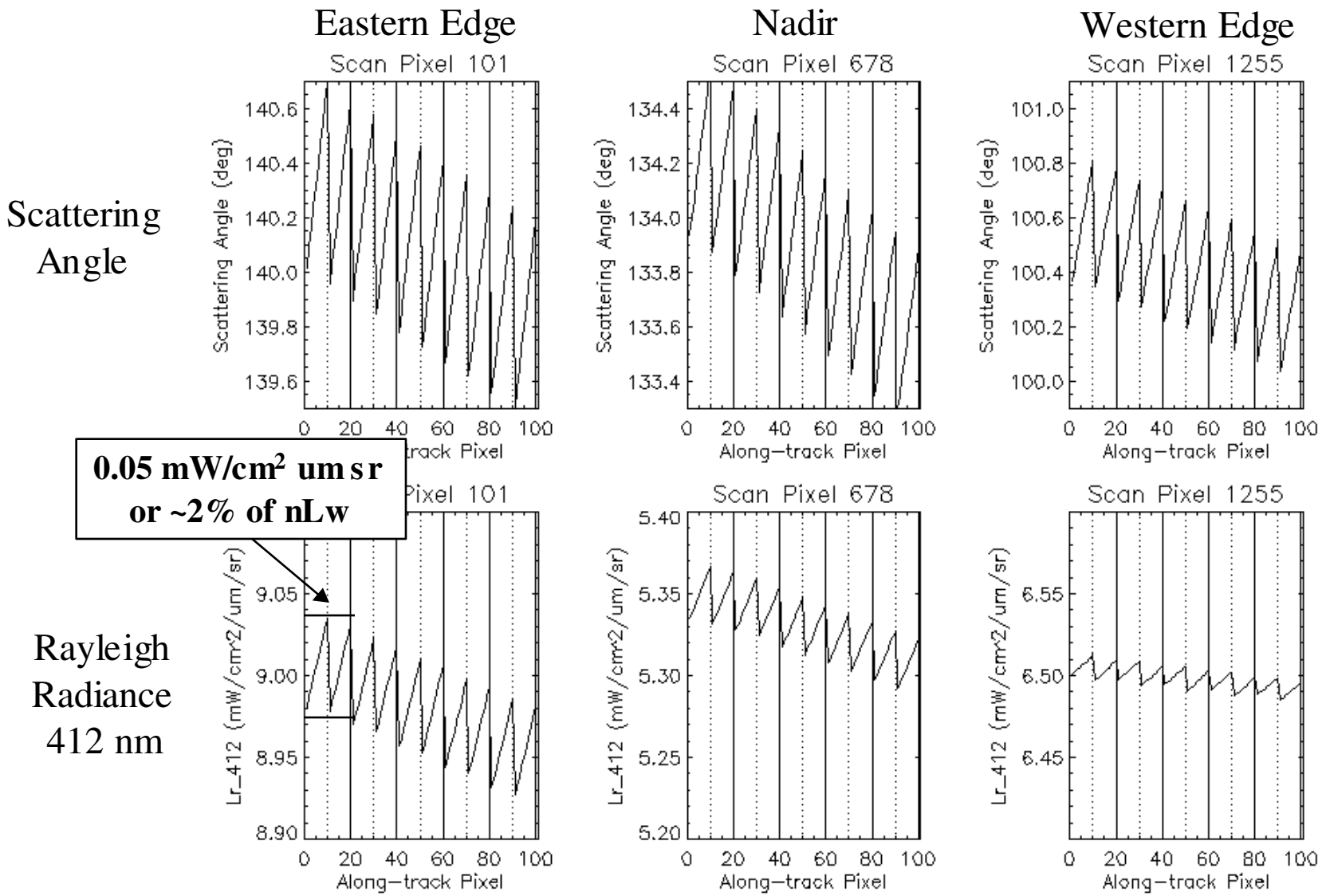




Scattering Angle

# Variation of Rayleigh Radiance Along-Track

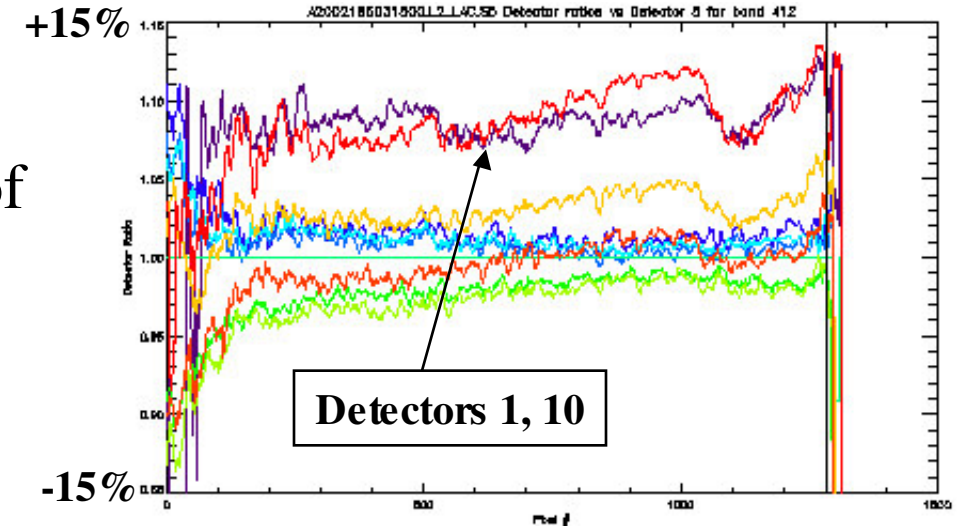



This means, for oceans, we can not use simple statistical methods on TOA signal (e.g., histogram equalization) to remove residual striping.

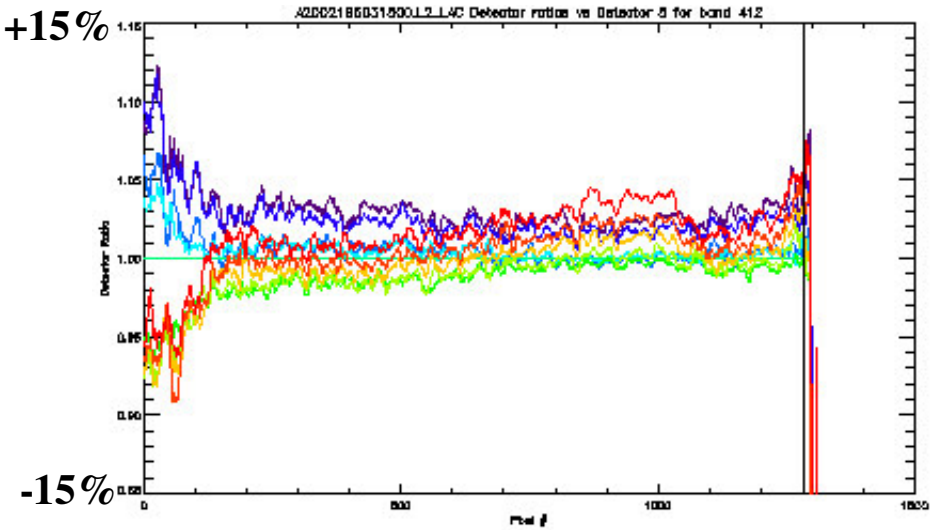
# Effect of MCST Solar Diffuser Destriping Correction

surface reflectance at 412nm, normalized to detector 5

Before application of detector-dependent SD calibration.



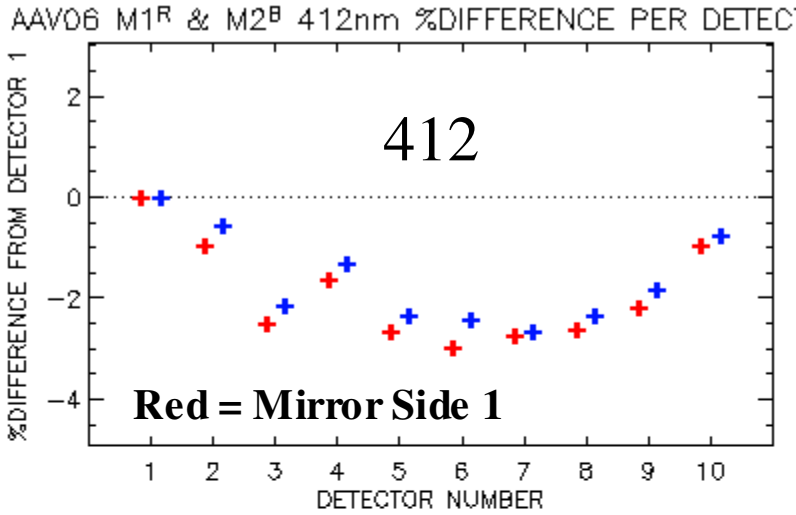

After application of detector-dependent SD calibration.

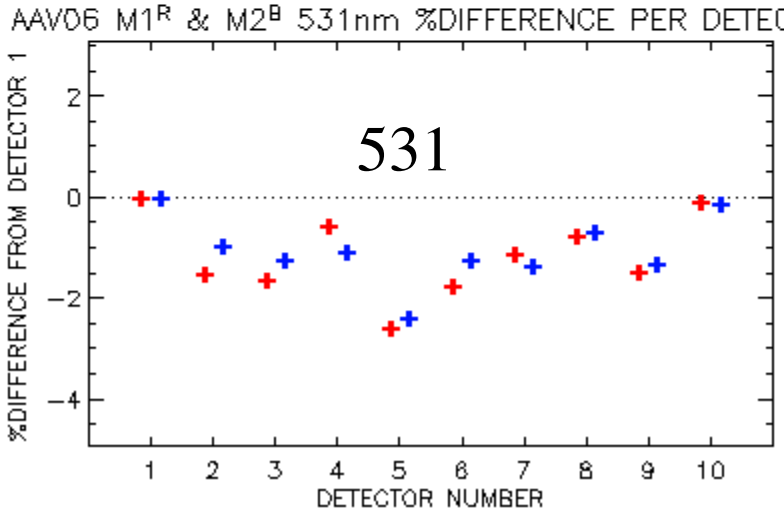


# Residual Striping in nLw

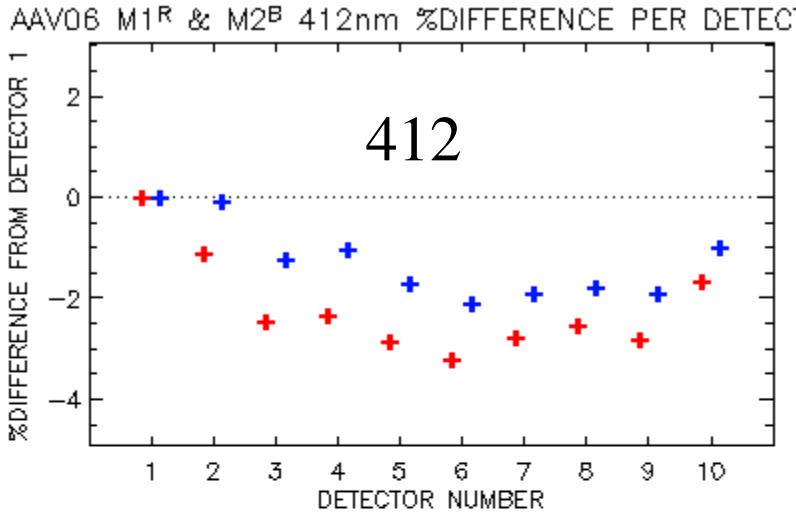
## Mean % Difference per Detector Relative to 7-Day Mean

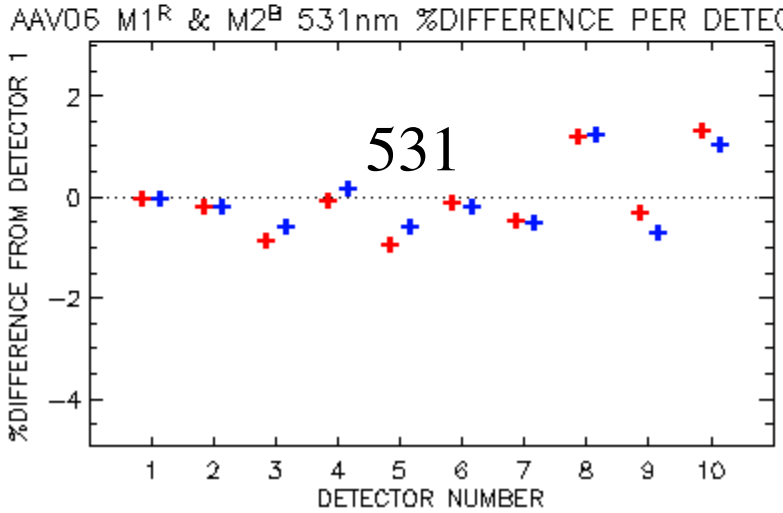
### Early Mission




### Late Mission



# Effects of BRDF on Scan-Dependence of MODIS/Aqua nLw

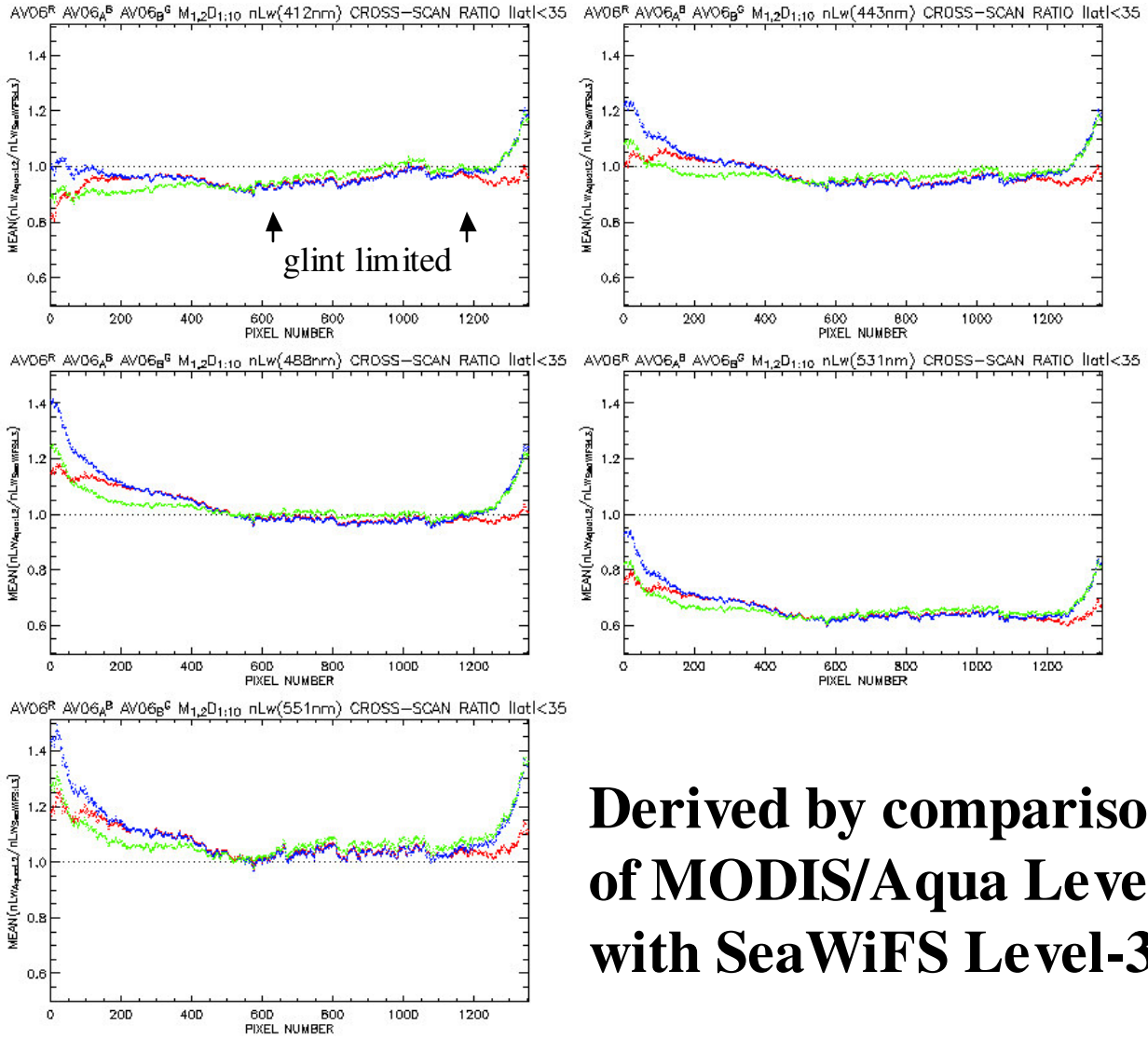
## *low chl water (C < 0.15 mg/m³)*

## day 2002 226

**Fresnel**
**Red**

**Morel ℜ**
**Blue**

**Morel ℜ + f/Q**
**Green**

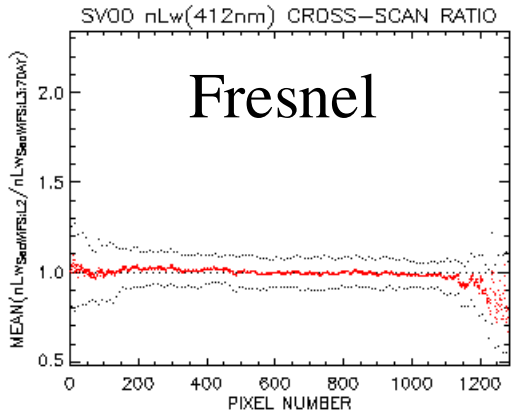


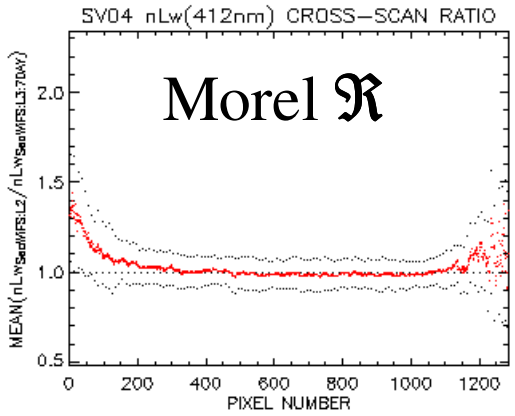

**Derived by comparison of MODIS/Aqua Level-2 with SeaWiFS Level-3.**

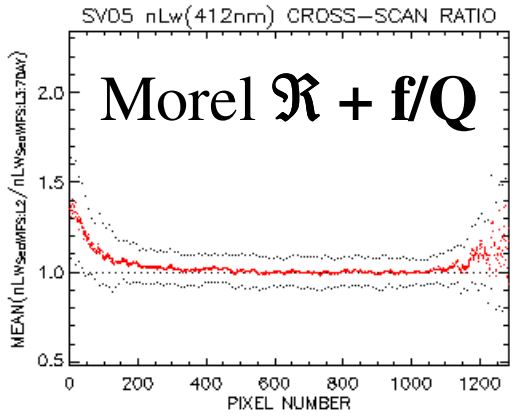
# Effects of BRDF on Scan-Dependence of SeaWiFS nLw

## *clear water (C < 0.15 mg/m³)*

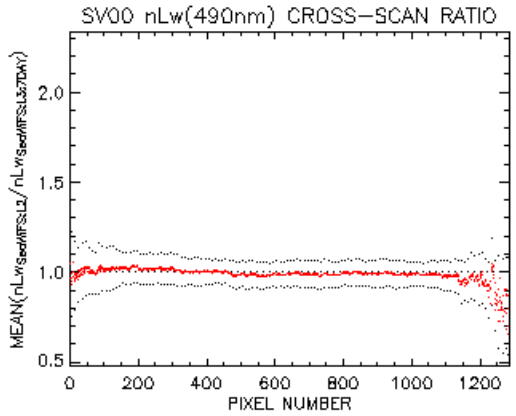
412

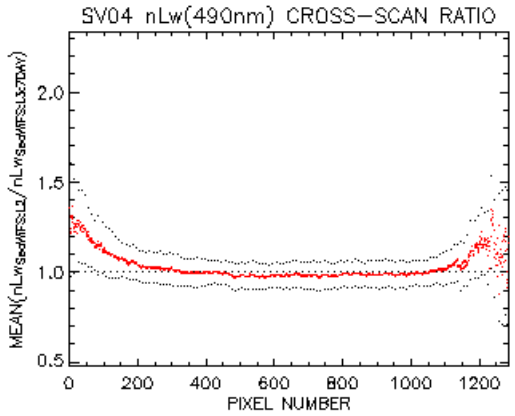


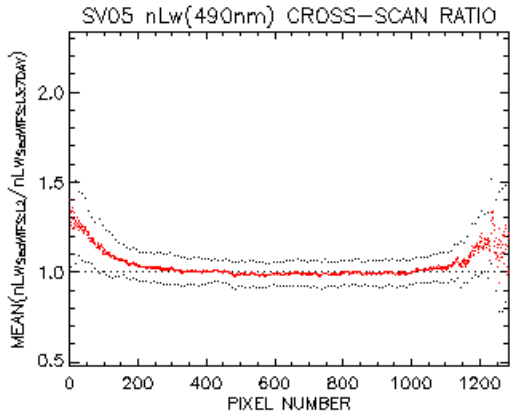



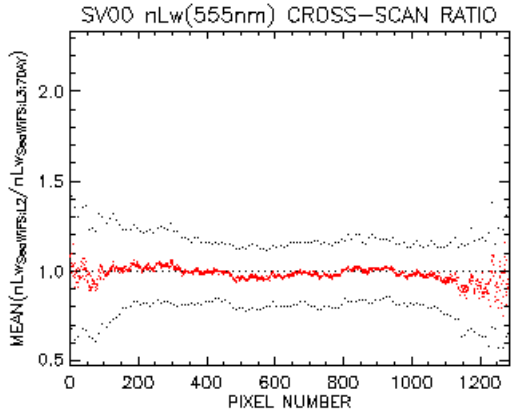

490

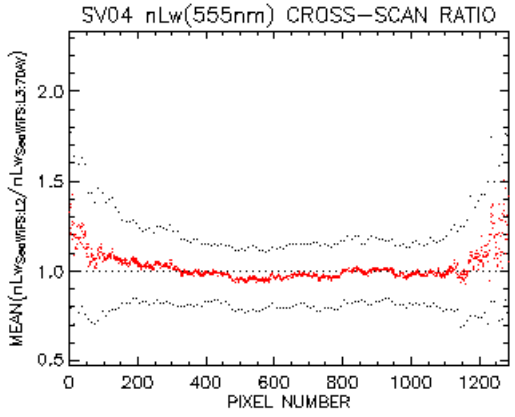


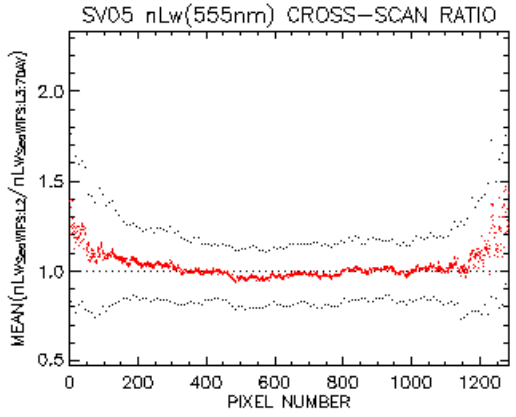




555



# Reducing RVS and Striping Artifacts
# Instrument Approach

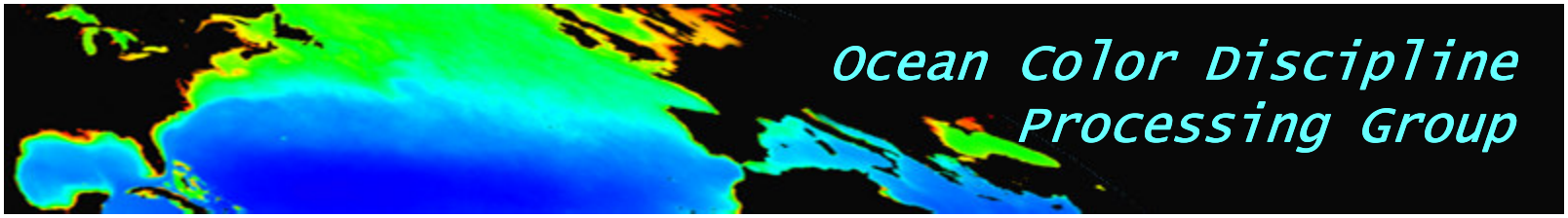
- On-board calibration: evaluate alternate LUTs
  - no detector-dependence in SD m1s
  - alternate temporal models for fitting detector-dependent SD m1s
  - no RVS correction
  - just pre-launch RVS correction
  - pre-launch + 2-point (solar-lunar) time-dependent correction
  - pre-launch + 3-point (solar-lunar-srca) time-dependent correction (Terra)

- Pre-launch polarization
  - evaluate change to per-detector polarization sensitivity
  - optical models indicate that dependency should exist
  - preliminary tests show no benefit to Aqua
  - quality of Aqua pre-launch polarization measurements may not be sufficient to determine detector dependence

# Reducing RVS and Striping Artifacts
# Vicarious Approach

- Derive vicarious RVS per detector
  - calibrate MODIS to multi-day MODIS Level-3 composite
    - detector and scan-dependence minimized in Level-3
  - derive mean gain per band, detector, mirror-side at each scan pixel
  - capability is in development

- Derive vicarious RVS and polarization sensitivity per detector
  - calibrate MODIS using SeaWiFS Level-2 nLw and/or aerosol retrievals
    - SeaWiFS is stable with time, insensitive to polarization
    - provides global distribution of predicted TOA radiances to characterize effects with varying viewing and solar geometry.
    - band-pass differences must be accounted for via spectral models (Morel)
    - added uncertainty due to time-of-day differences (BRDF)
  - simultaneous optimization for scan-dependent gain and polarization sensitivities (M11, M12, M13) per band, detector, mirror-side
  - initial results are now being evaluated



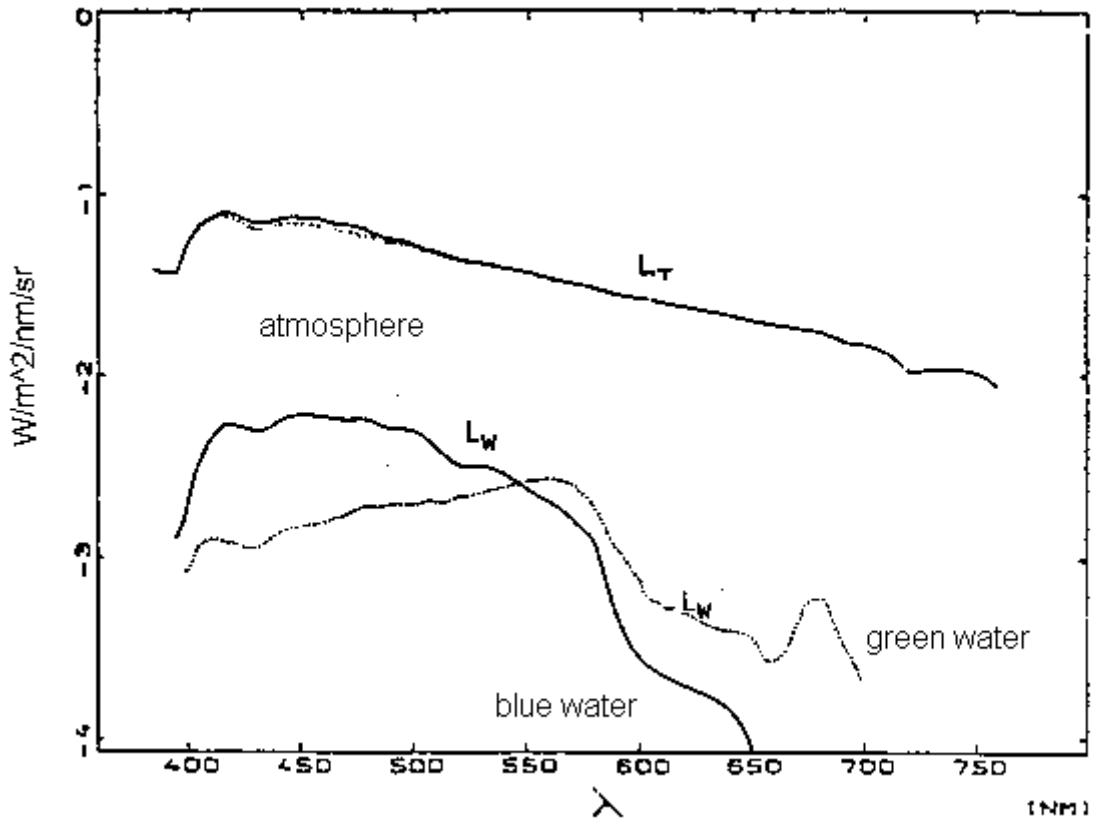

# MODIS Calibration and Characterization
## Effects on Ocean Color

Bryan Franz

*SAIC*

Ocean Color Discipline Processing Group

# Ocean Product Sensitivity to Calibration




A 1% error in TOA radiance translates to an error of 10% or more in retrieved water-leaving radiances.

# MODIS/Aqua Calibration and Algorithm Testing

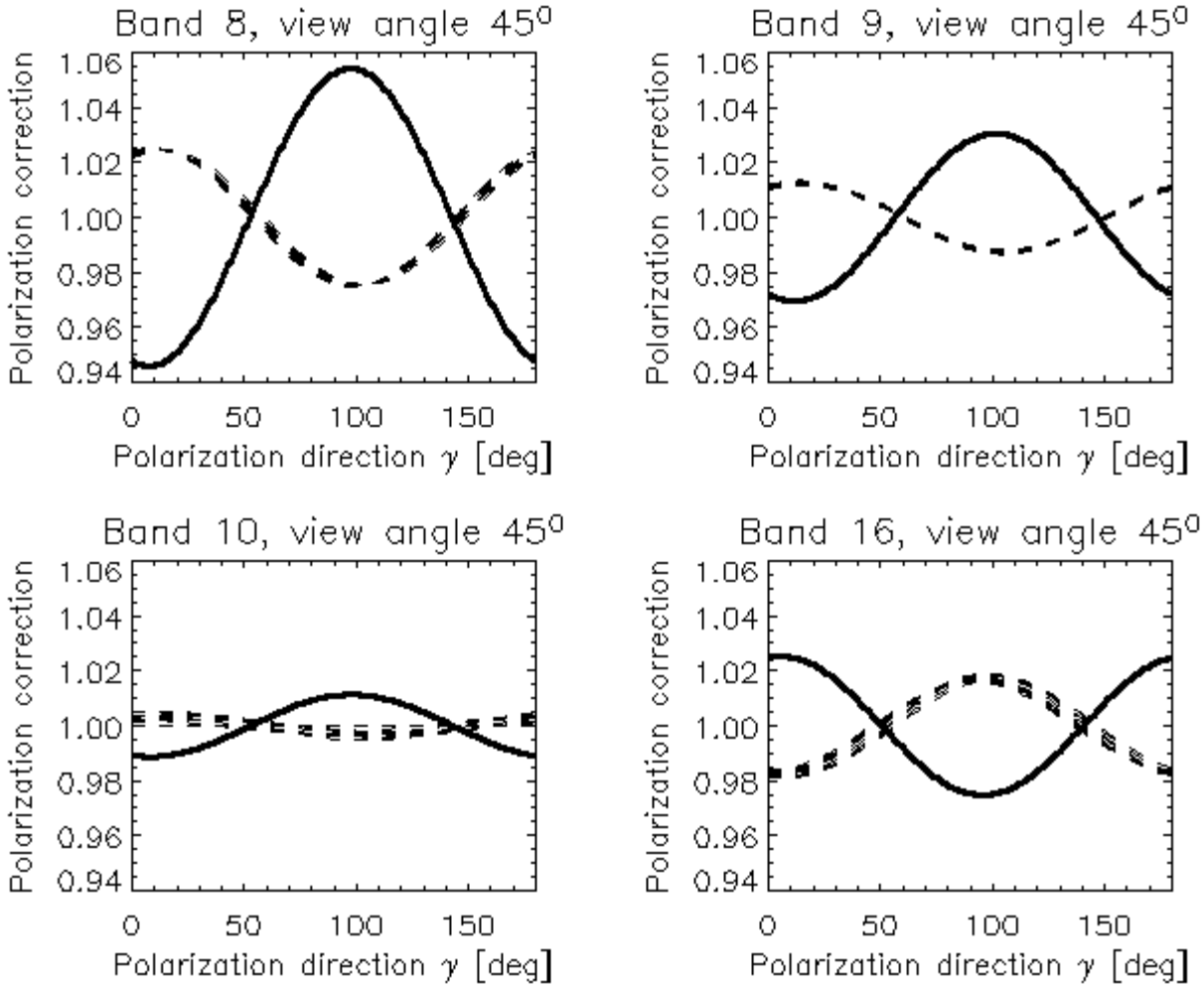
- Perform independent evaluation of each potential change in calibration or processing algorithms
  - relative to previous configuration
  - relative to *in situ*
  - relative to SeaWiFS

- For each potential change:
  - recompute vicarious calibration (one gain per band for all time)
  - re-evaluate *in situ* match-ups
  - evaluate temporal trends over entire mission
    - process first 4-days of each 32-day period
    - reduce to common bins with SeaWiFS
    - compare global and regional averages over time
  - complete evaluation in approximately 2 days

# Aqua Calibration and Algorithm Test Sequence

- **AT01: Fresnel BRDF, no polarization correction, log-fitted L1B LUT**
- AT02: AT01 with standard polarization correction
- AT03: AT01 with corrected phase polarization correction
- AT04: AT03 with Gothic-R BRDF
- AT05: AT03 with Gothic-R + f/Q BRDF
- **AT06: AT01 with corrected phase and magnitude polarization correction**
- AT07: AT06 with HIGLINT masking
- AT08: AT07 with reduced cloud threshold (0.027)
- AT09: AT06 with reversed polarizer rotation
- AT10: AT07 with reduced cloud threshold (0.022)
- AT11: AT08 with updated L1B LUT (V4.3.1.5S)
- AT12: AT11 with Fresnel + f/Q BRDF
- AT13: AT15 with alternate L1B LUT (piece-wise polynomial fit)
- AT14: AT11 with modified polarization (NIR from Terra)
- AT15: AT11 with updated vicarious calibration

**Solid line: AT06 polarization correction**
**Dashed line: original polarization correction**

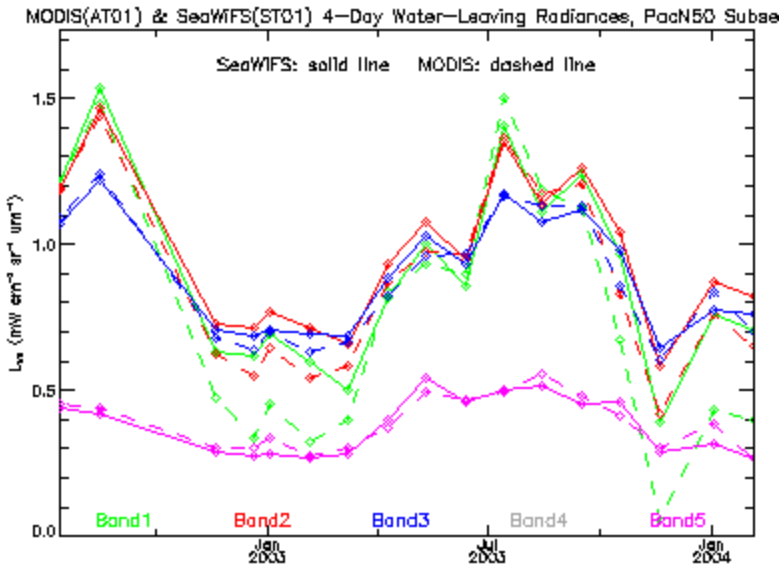


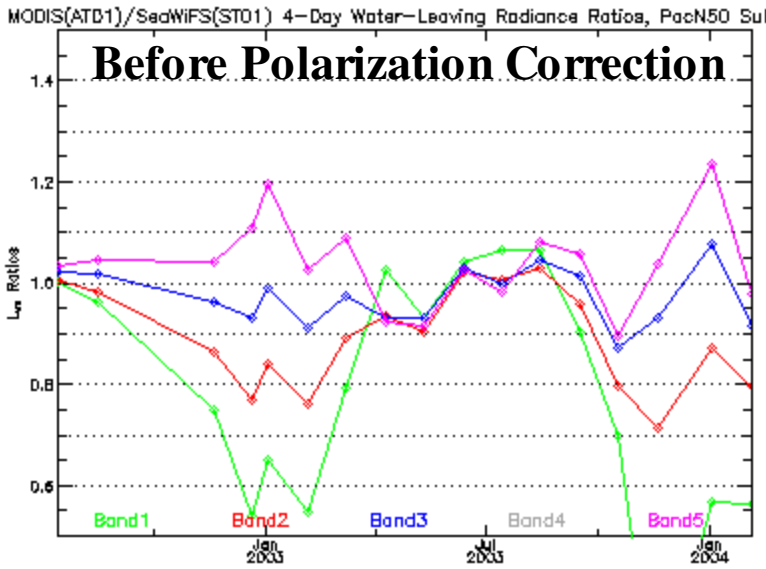
# nLw: MODIS/Aqua vs SeaWiFS

**NH**

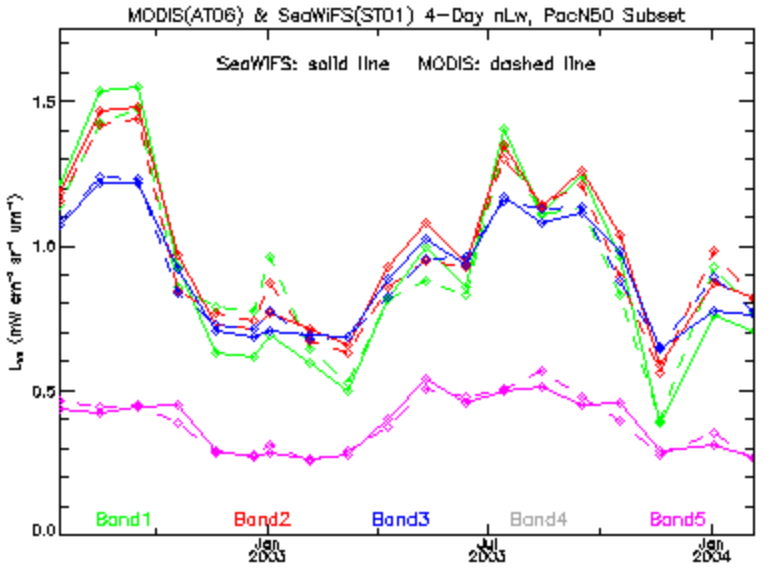
## **50N-40N**, 150W-170W

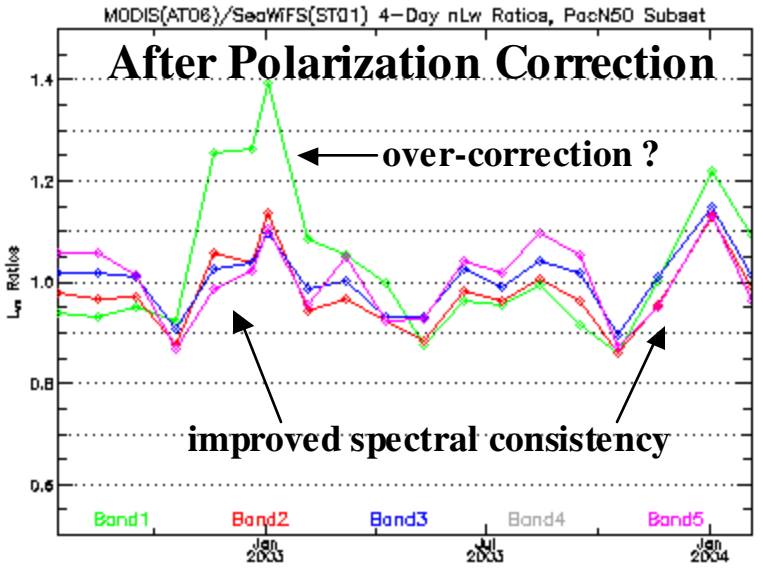
**AT01**




**AT06**



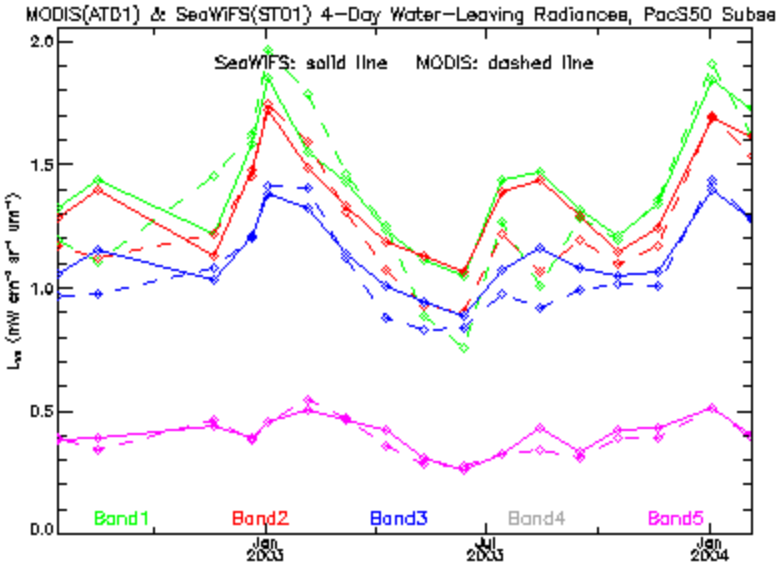



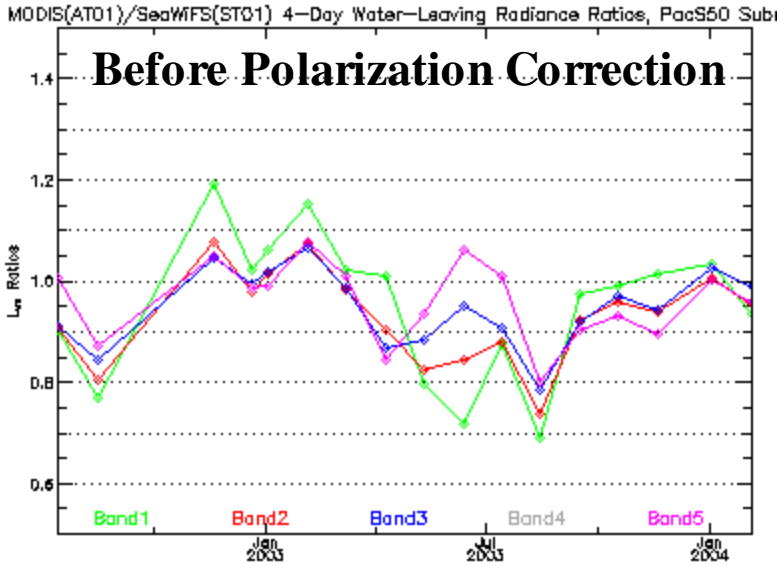
# nLw: MODIS/Aqua vs SeaWiFS

**SH**

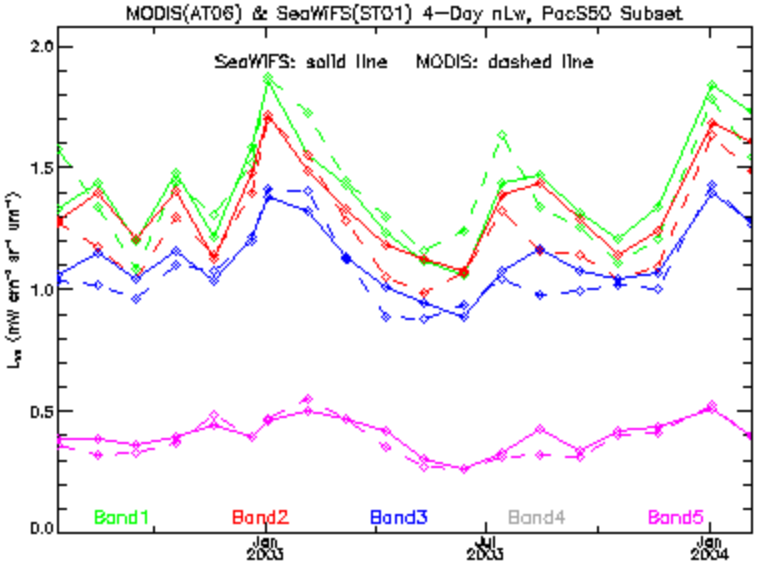
## **50S-40S**, 150W-170W

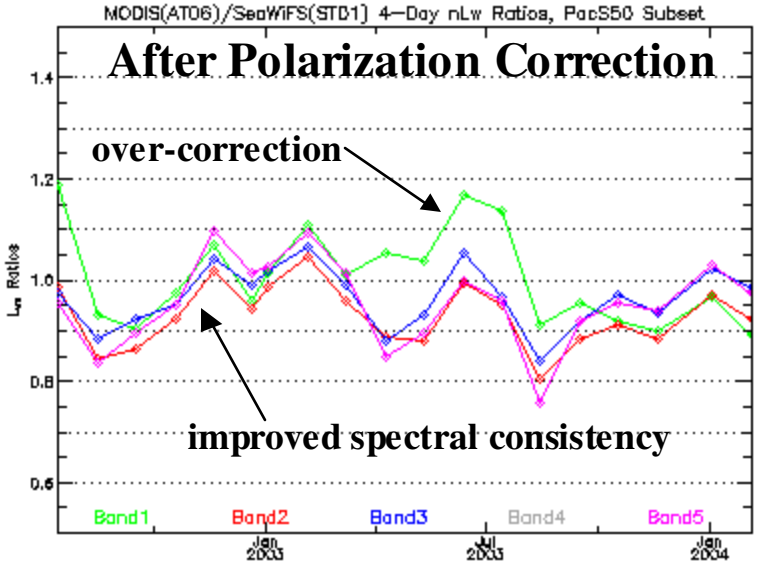
**AT01**



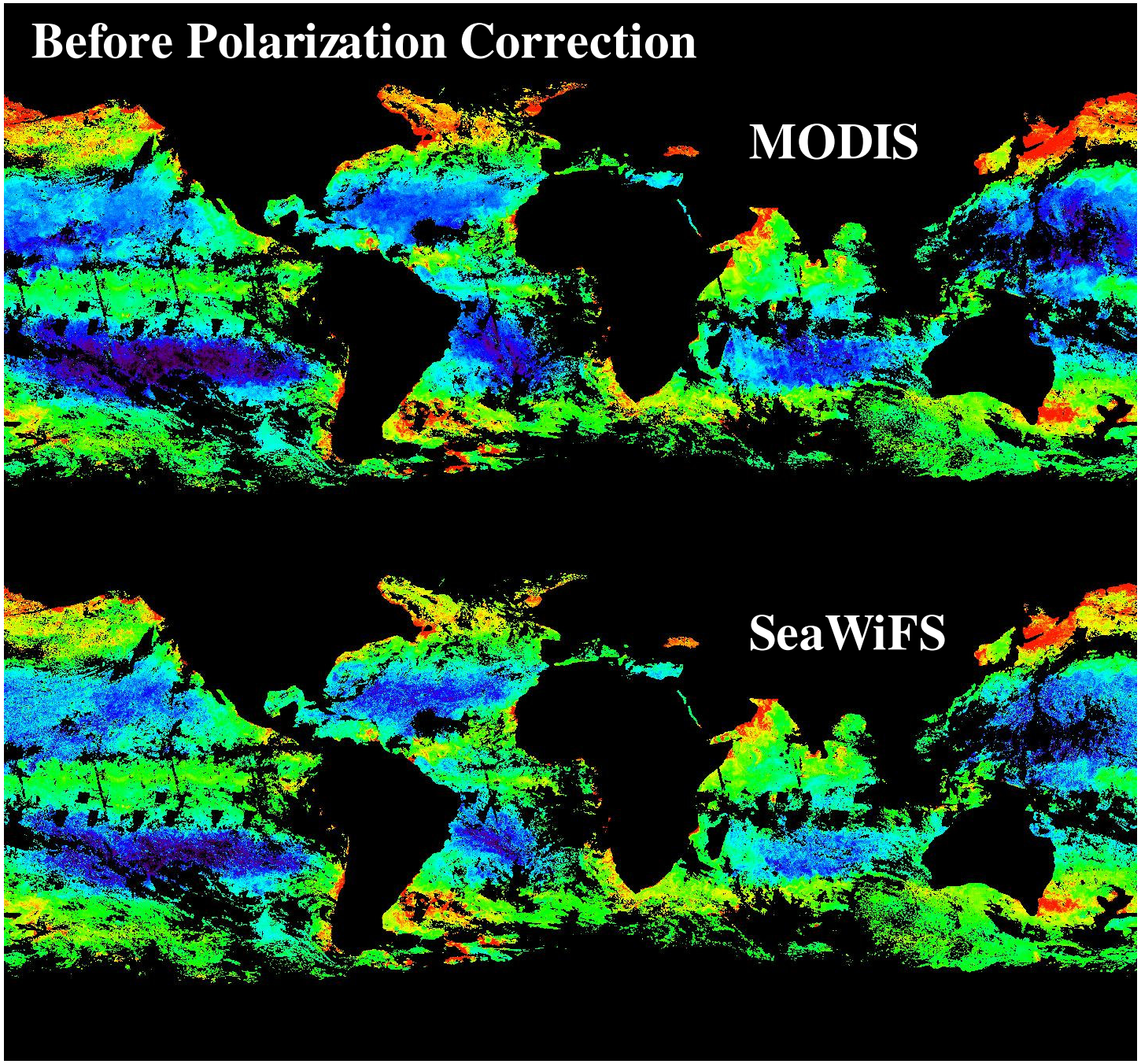

**AT06**



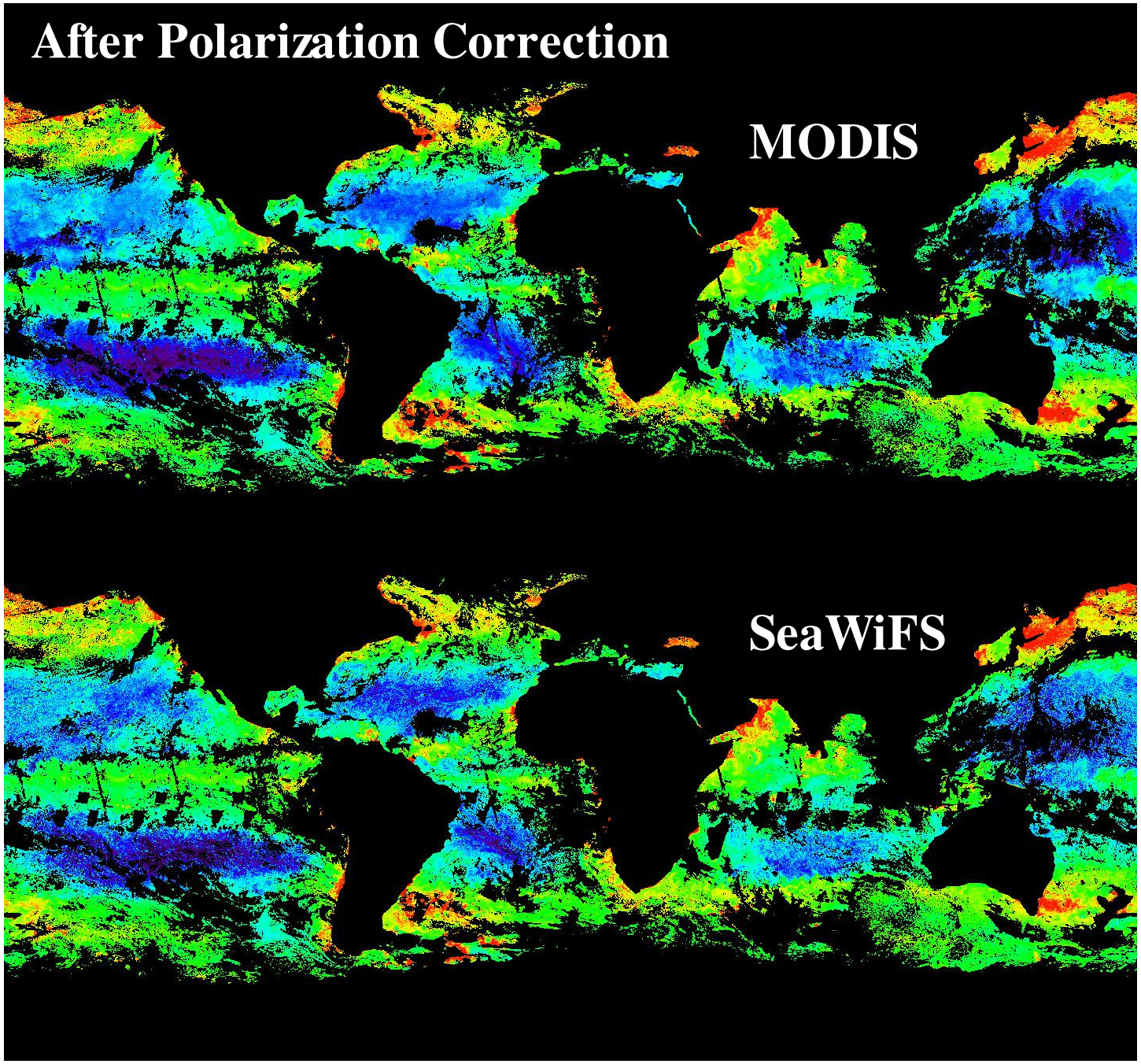
AT01

ST03



AT06

ST03



# Aqua Calibration and Algorithm Test Sequence

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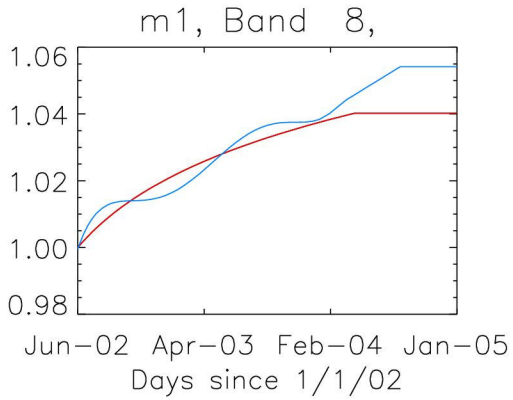
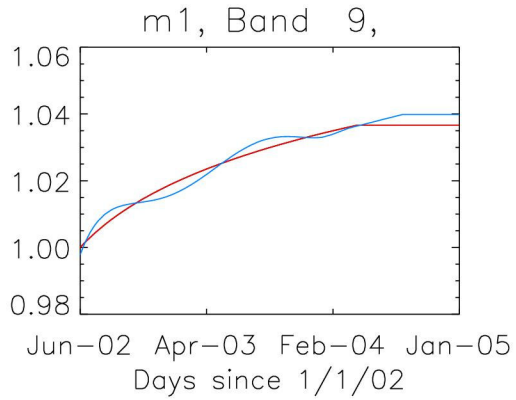
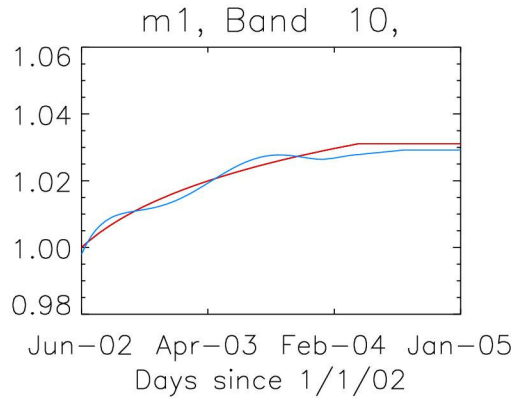
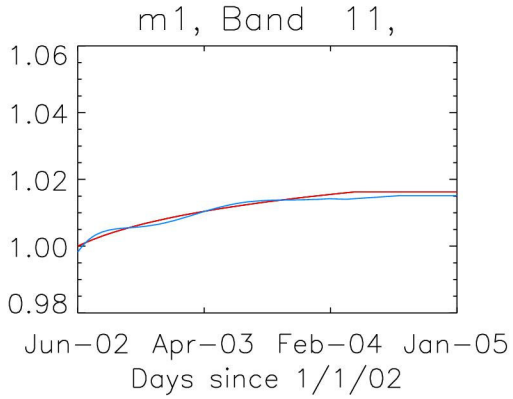
- AT12: AT11 with Fresnel + f/Q BRDF
- **AT13: AT15 with alternate L1B LUT (piece-wise polynomial fit)**
- AT14: AT11 with modified polarization (NIR from Terra)
- **AT15: AT11 with updated vicarious calibration**

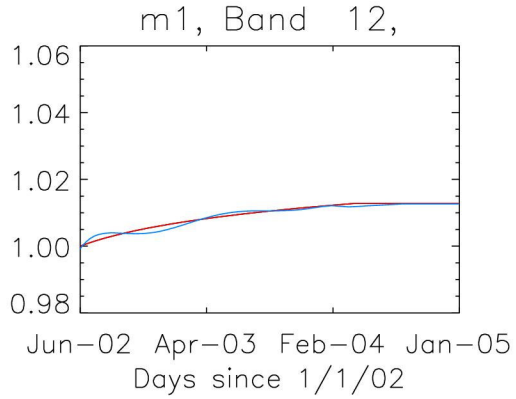
# Log-fit m1 (red) and piece-wise polynomial m1 (blue)

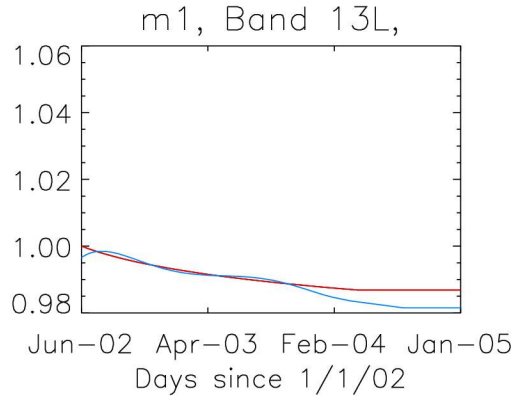


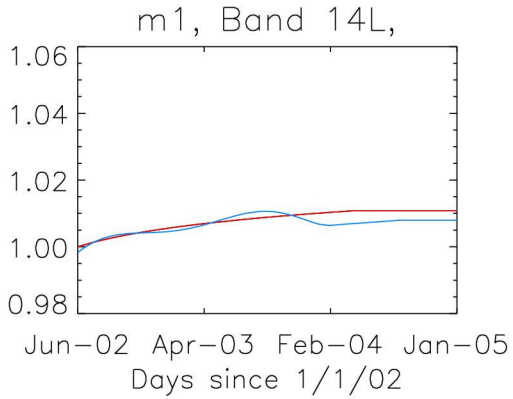



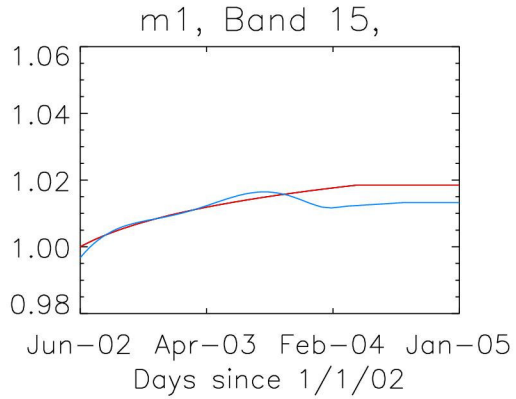



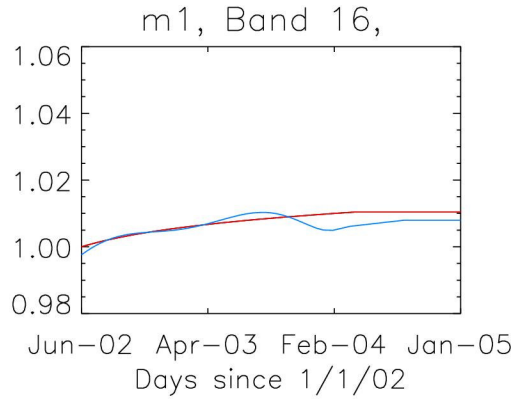



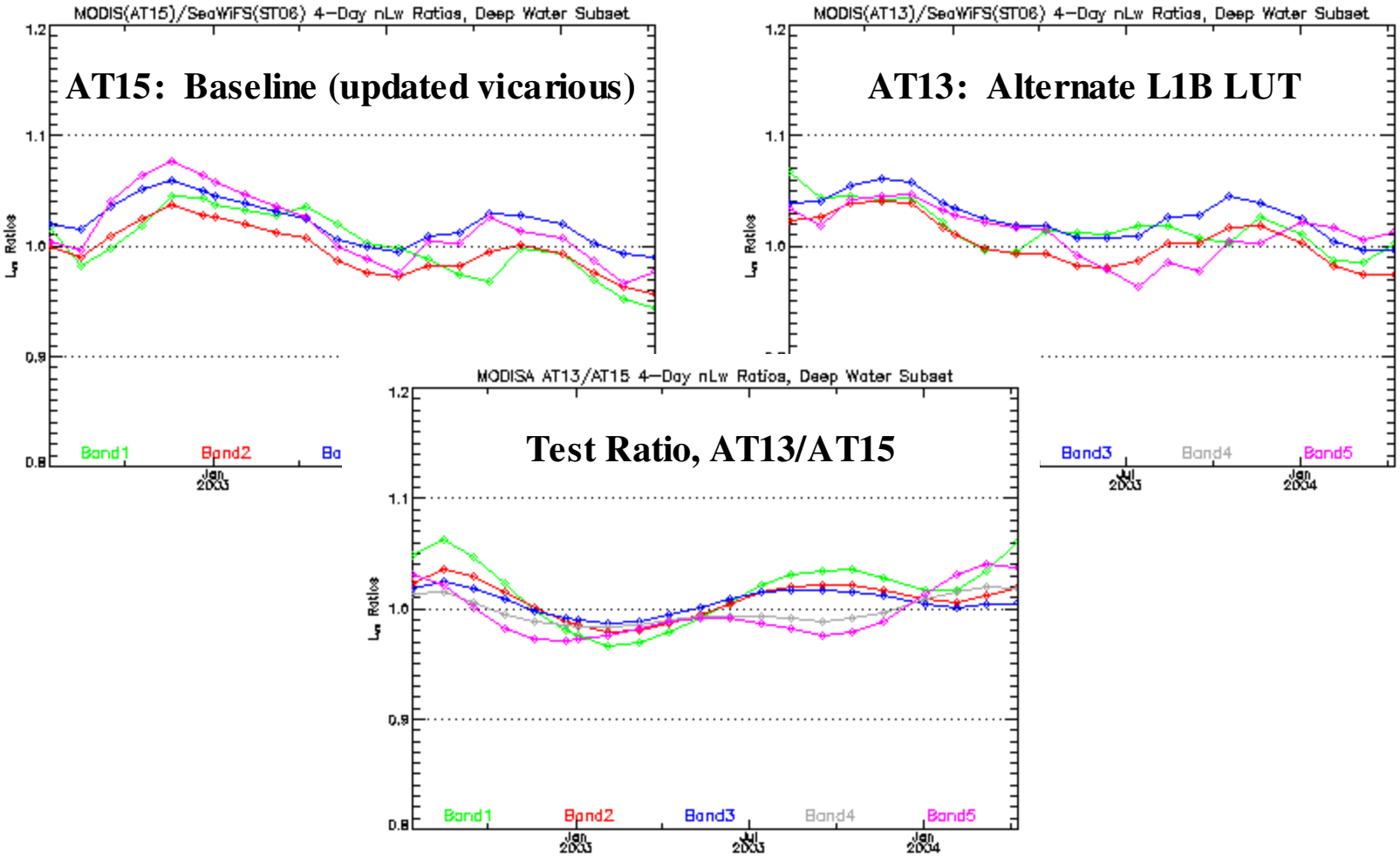



# nLw: MODIS/Aqua vs SeaWiFS

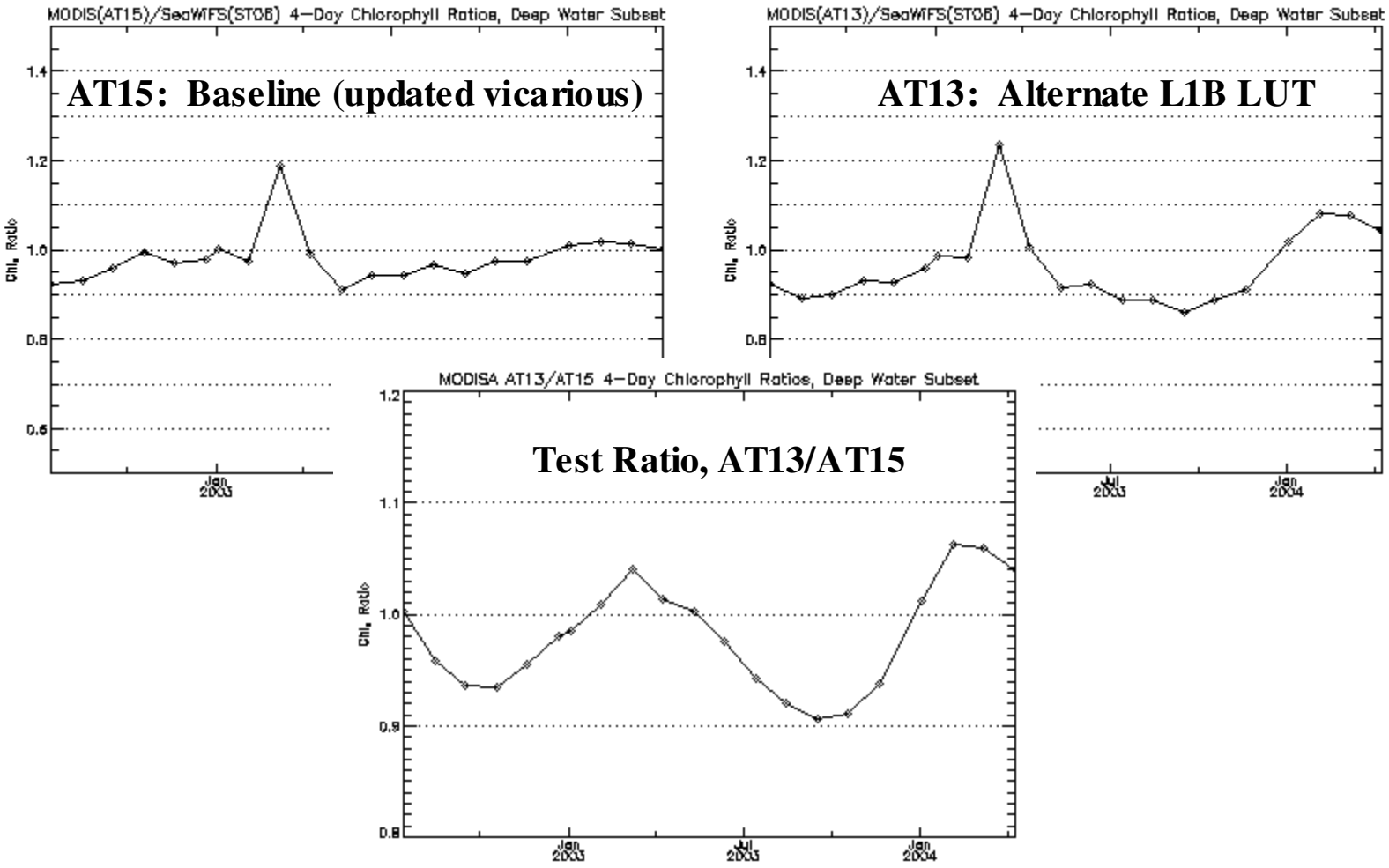
## Deep-Water




Effect of alternate L1B LUT, piecewise polynomial fit to SD m1s.

# nLw: MODIS/Aqua vs SeaWiFS

## Deep-Water




Effect of alternate L1B LUT: piecewise polynomial fit to SD m1s. Increased variability in chlorophyll relative to SeaWiFS.

# MODIS/Aqua R0 Processing Decisions

- Multiple MCST LUTs evaluated
  - measured m1
  - smoothed, log-fitted m1
  - piece-wise polynomial m1
  - use log-fitted m1 with periodic updates for baseline processing

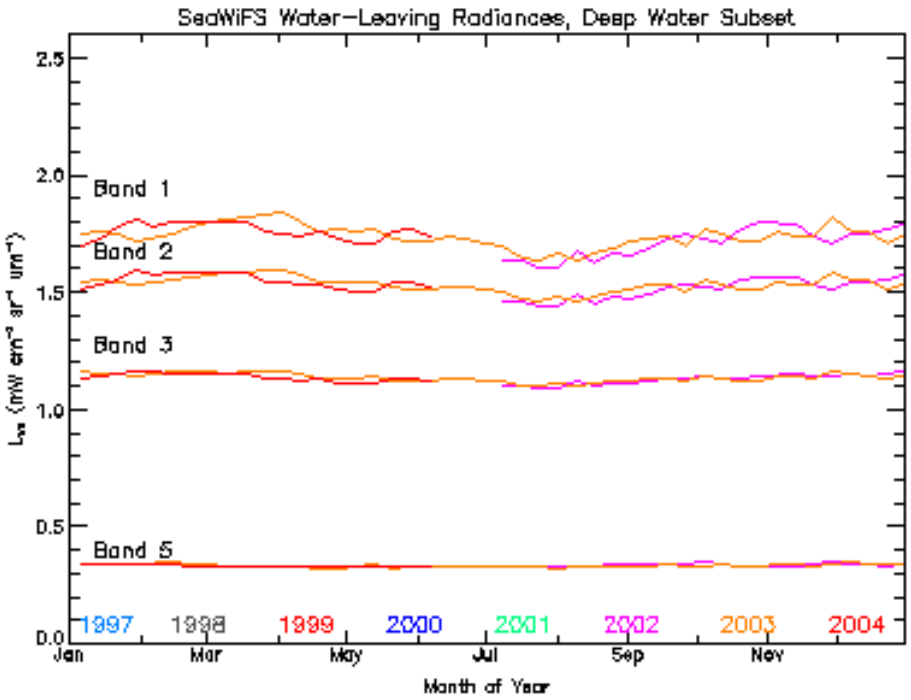
- Polarization sensitivity (see poster by Meister et al.)
  - laboratory set-up and test results re-evaluated
  - new sensitivities derived (2x magnitude, phase-shifted)
  - new polarization corrections adopted for baseline reprocessing

- Vicarious calibration
  - one gain per band for all time
  - visible bands determined using MOBY
  - NIR bands determined using assumed aerosol-type

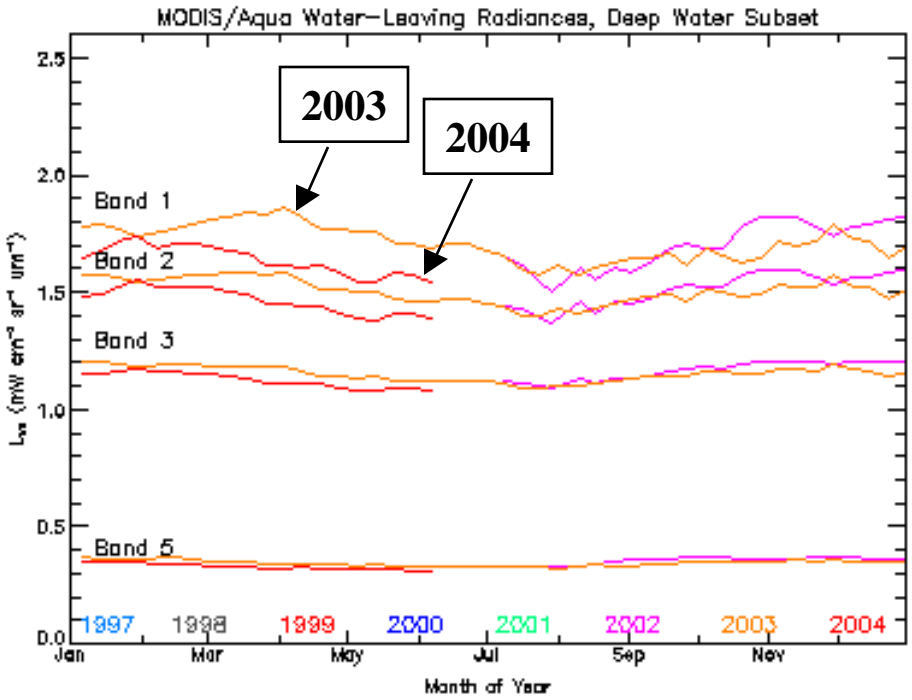
# Annual Repeatability in nLw

## Deep-Water Subset, 8-Day Bins

### SeaWiFS R4



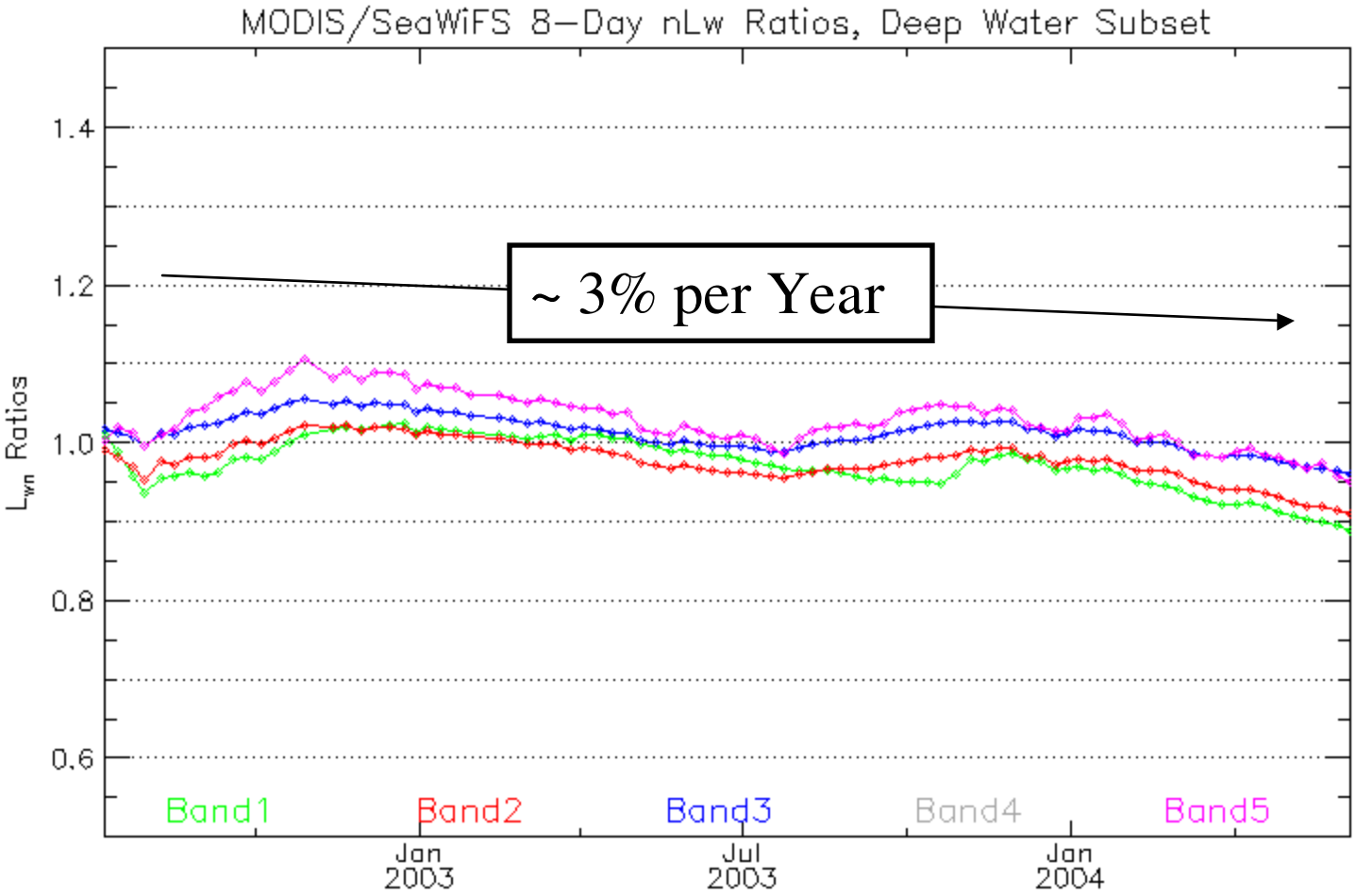

### MODIS/Aqua R0




Temporal stability of MODIS/Aqua still not demonstrated.

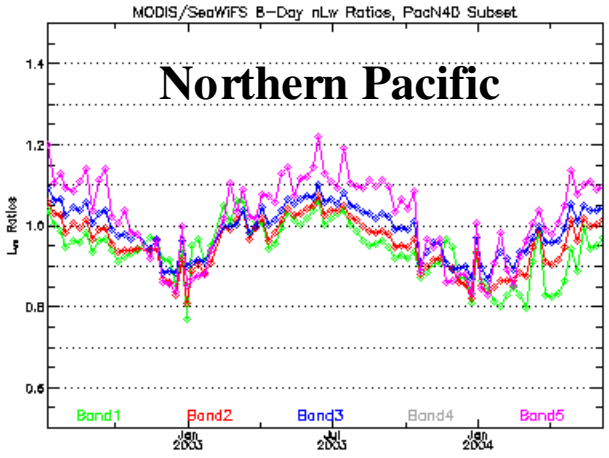
# nLw: MODIS/Aqua vs SeaWiFS

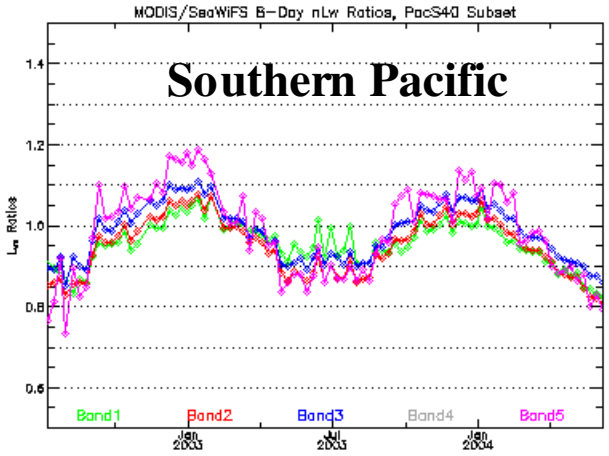
## Deep-Water

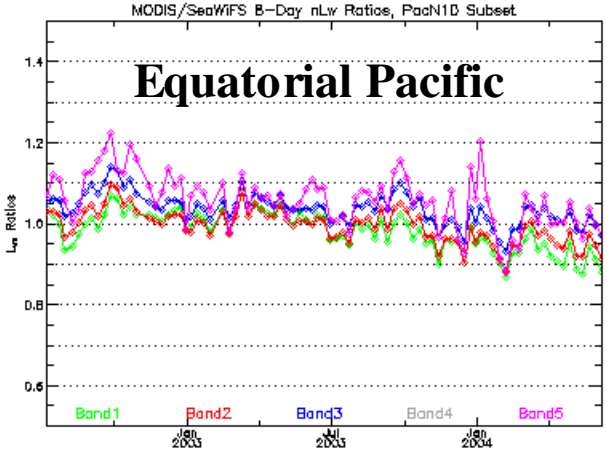



MODIS/Aqua water-leaving radiances show long-term decay relative to SeaWiFS, in addition to a seasonal cycle.

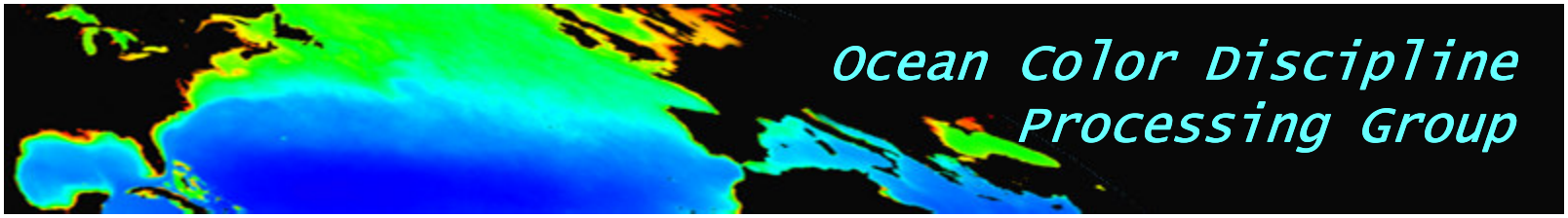
# nLw: MODIS/Aqua vs SeaWiFS




Seasonal differences of +/- 10% between SeaWiFS and MODIS/Aqua still evident at high latitudes (high solar zenith). After polarization correction, behavior is spectrally consistent, but cause is unknown.




# Product Development

Bryan Franz

*SAIC*

Ocean Color Discipline Processing Group

# Calibration Updates

- Multiple MCST LUTs evaluated
  - measured m1
  - smoothed, log-fitted m1
  - piece-wise polynomial m1
  - use log-fitted m1 with periodic updates for baseline processing
  - http://seawifs.gsfc.nasa.gov/staff/franz/l3trend/modisa_testing.html

- Vicarious calibration
  - one gain per band for all time
  - visible bands determined using MOBY
  - NIR bands determined using assumed aerosol-type
  - calibration re-evaluated for each test configuration
  - http://seabass.gsfc.nasa.gov/cgi-bin/vicarious.cgi?sensor=a

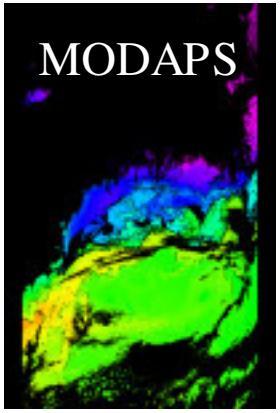
# Algorithm Updates

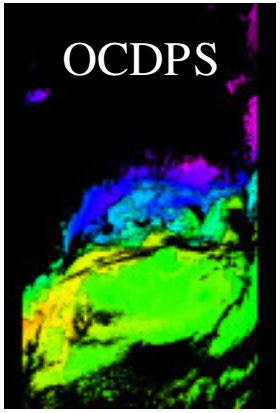
- Polarization sensitivity correction
  - laboratory set-up and test results re-evaluated
  - new sensitivities derived (2x magnitude, phase-shifted)
  - a series of test were performed to verify improvement
    - temporal trend comparisons with SeaWiFS
  - new polarization corrections adopted for baseline reprocessing
  - http://seawifs.gsfc.nasa.gov/staff/franz/l3trend/modisa_testing.html
  - http://oceancolor.gsfc.nasa.gov/DOCS/polcormemo.pdf

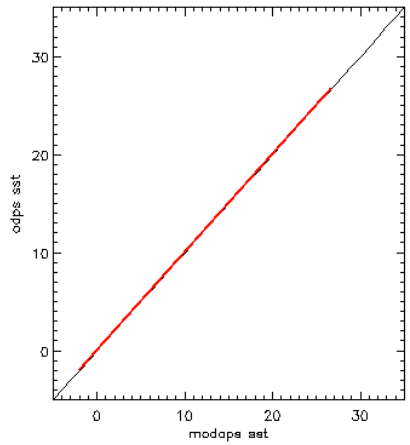
- Bi-directional reflectance correction
  - several strategies evaluated: Fresnel, Morel R, Morel R + f/Q, Fresnel + Morel f/Q
  - decision to stay with Fresnel for baseline processing
  - http://seawifs.gsfc.nasa.gov/staff/franz/l3trend/modisa_testing.html
  - http://seabass.gsfc.nasa.gov/eval/fq.cgi

# Derived Product Updates

- SST
  - enhanced to allow use of Reynolds OI SST as input
  - detailed intercomparison with MODAPS products performed
  - **exact match** demonstrated at Level-2 (given same input SST)
    - required correction of MODAPS code for OISST interpolation error



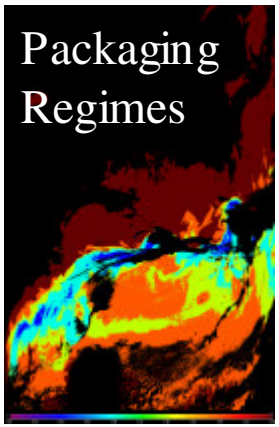




  - only remaining issue is Level-3 quality masking
    - MODAPS approach has been analyzed in detail
    - implementation plans TBD

  - http://seabass.gsfc.nasa.gov/eval/sst.cgi

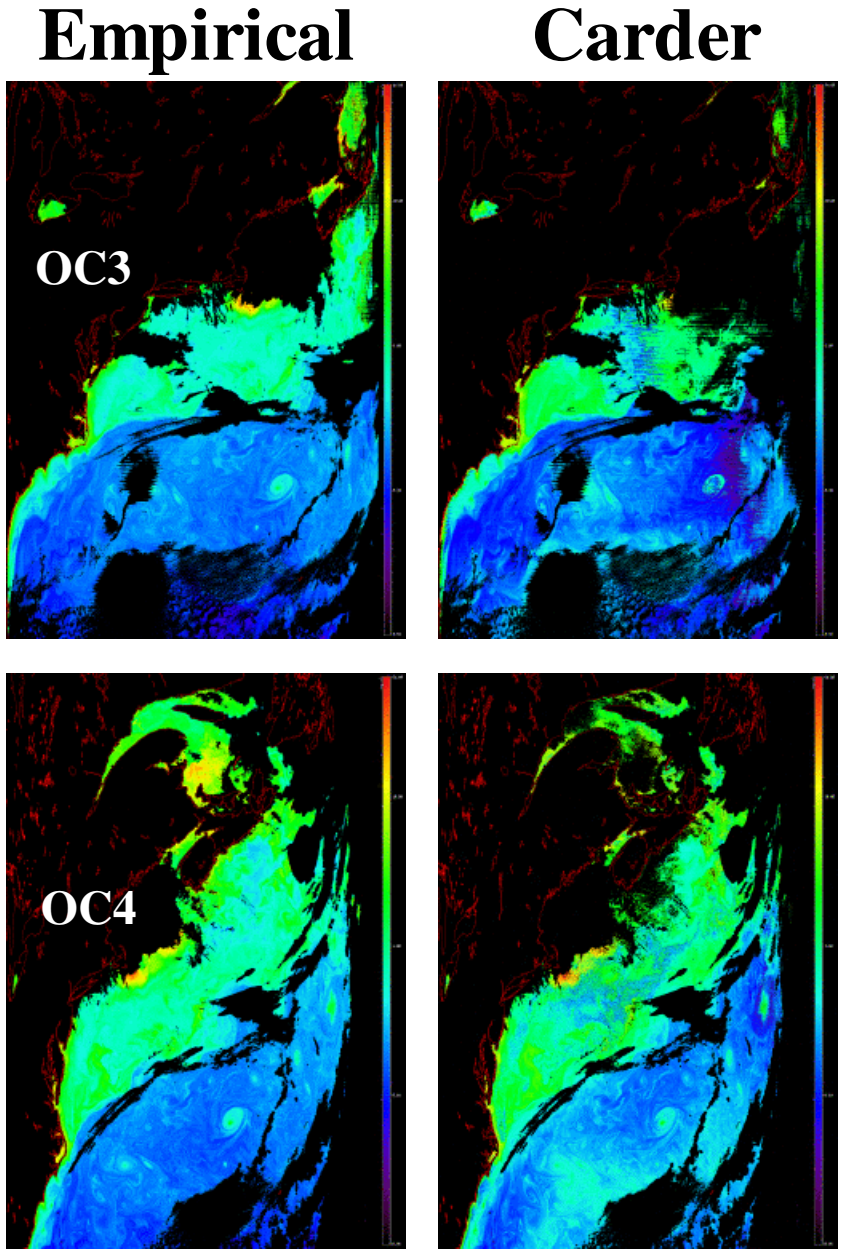
# Additional Derived Products

- Fluorescence Line Height
  - implementation in progress




- Carder Chlorophyll and IOP model
  - obtained existing code (MODIS and SeaWiFS variants)
  - implemented in MSl12
  - generalized for multiple sensors
  - tests performed to verify implementation
  - expected to be included with next SeaDAS update
  - **global processing TBD by Working Group recommendations**
  - http://seawifs.gsfc.nasa.gov/staff/franz/carder/
  - http://seabass.gsfc.nasa.gov/eval/usf.cgi

# Carder Chlorophyll Example

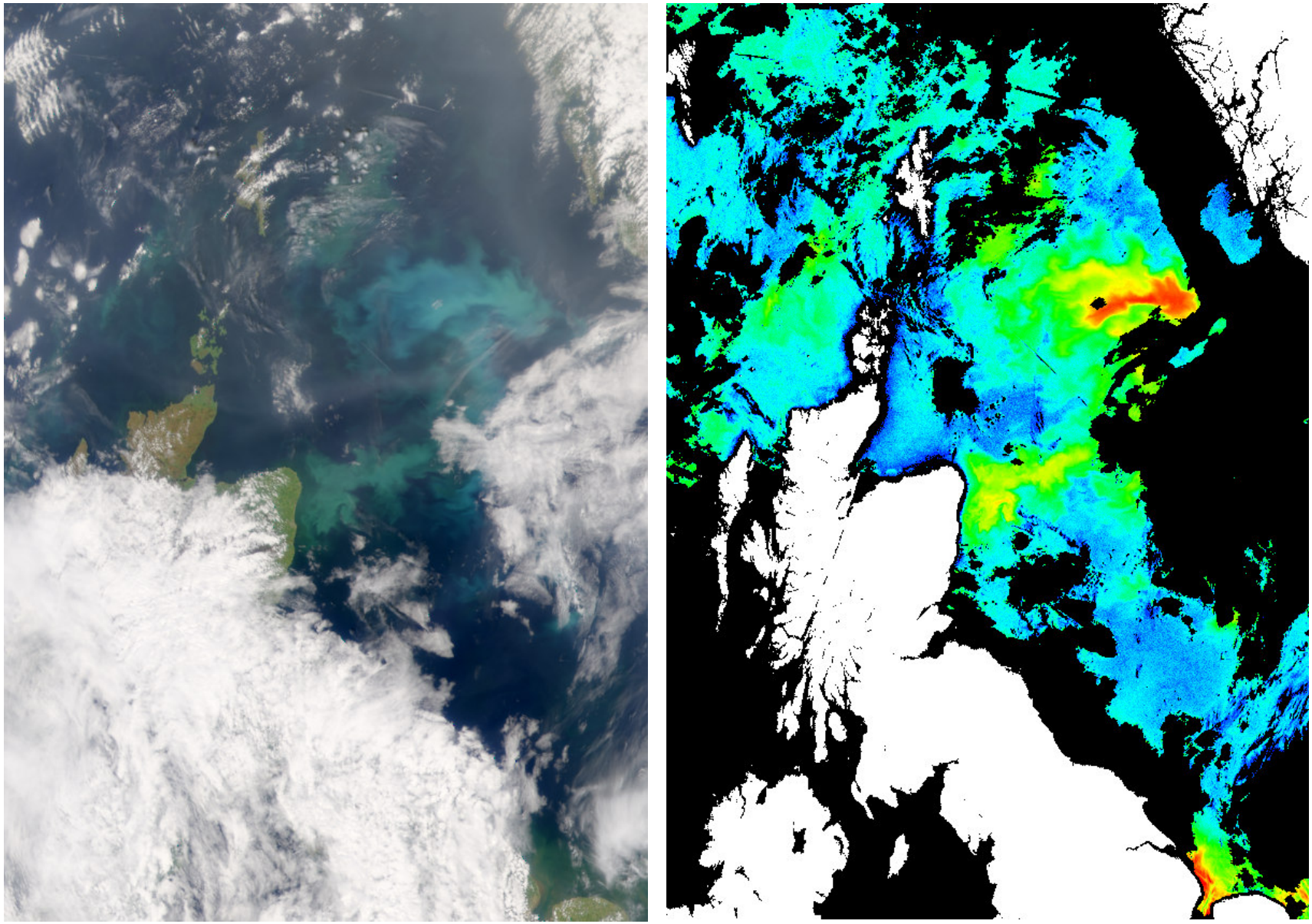


# Additional Derived Products

- Calcite, 2-band algorithm (Gordon, Balch, Boynton)
  - implementation in progress

- Calcite, 3-band algorithm (Gordon, Balch, Boynton)
  - obtained existing code (MODIS and SeaWiFS variants)
  - updated implemention in MSl12
    - generalized for multiple sensors
    - revised out-of-band correction
    - rewritten in C with improved iteration control
  - tests performed to verify implementation
  - expected to be included with next SeaDAS update
  - **global processing TBD by Working Group recommendations**

# Calcite, 3-band Algorithm



# Other Products Available in MSL12/SeaDAS

- Various empirical chlorophyll algorithms
  - OC2, OC3, Clark, etc.
- Garver, Siegel, Maritorena 2001 model
  - chl, bb, acdm
- Clark TSM & POC

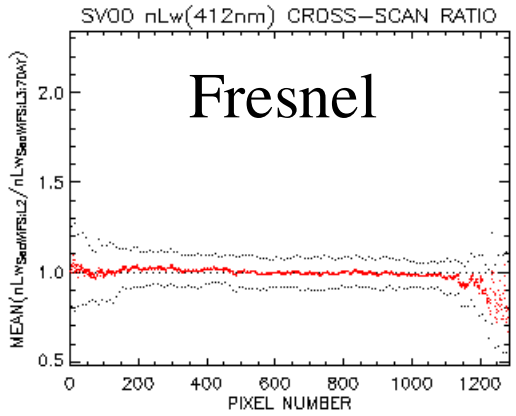
- Aerosol properties
  - AOT, Angstrom, models, etc.
- Various intermediate products
  - Lr, La, tLg, Rrs, etc.
- Ancillary fields
  - wind, pressure, ozone, SSTref, etc.

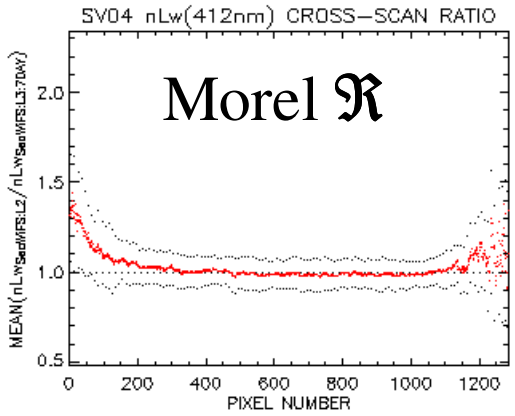
# BRDF Analyses

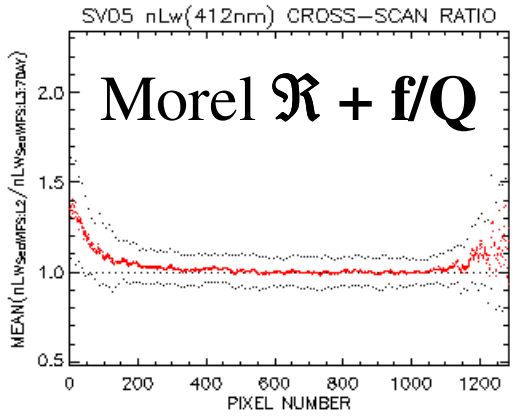
# Effects of BRDF on Scan-Dependence of SeaWiFS nLw

## *clear water (C < 0.15 mg/m³)*

412

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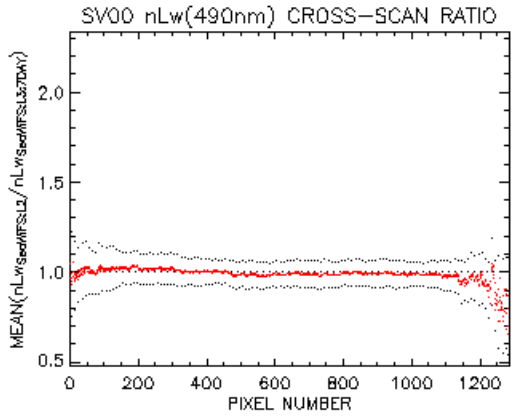
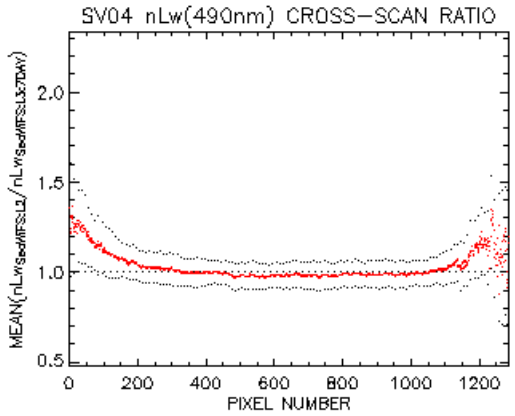
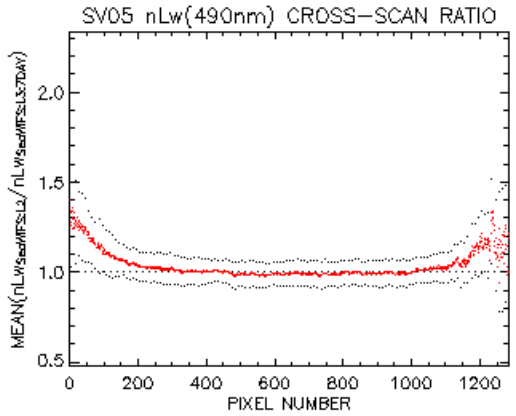
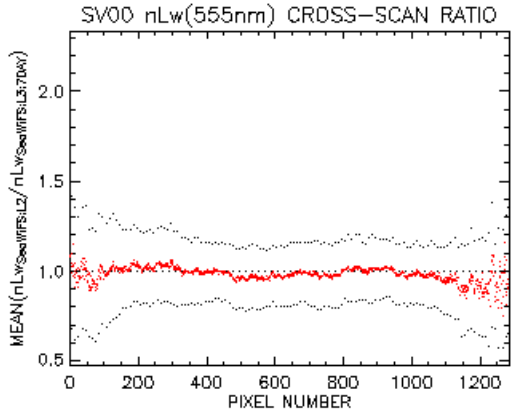
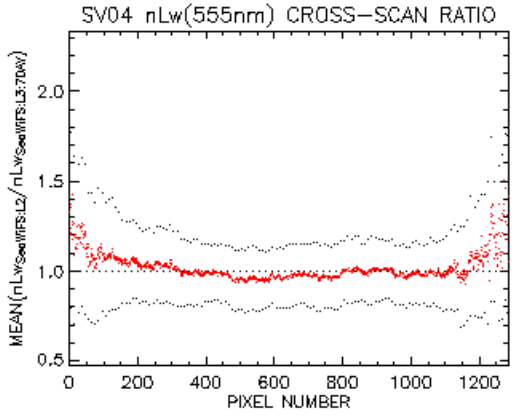


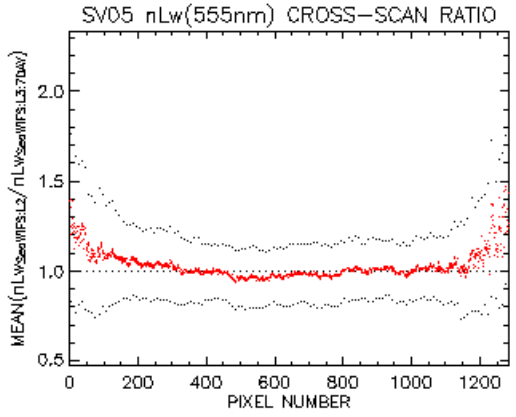




555



# Effects of BRDF on Scan-Dependence of SeaWiFS nLw

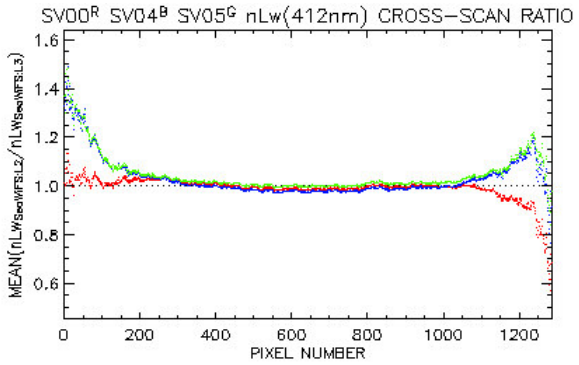
## *low chl water (C < 0.15 mg/m$^3$)*

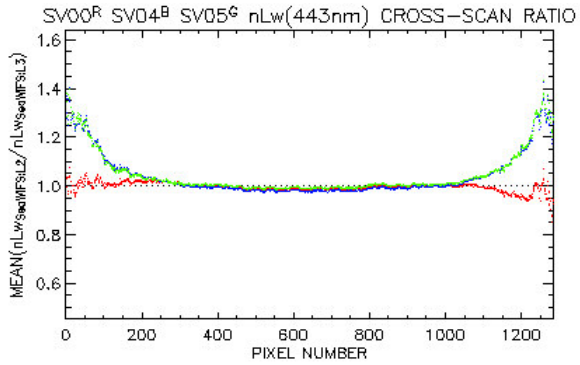
## day 2004 003

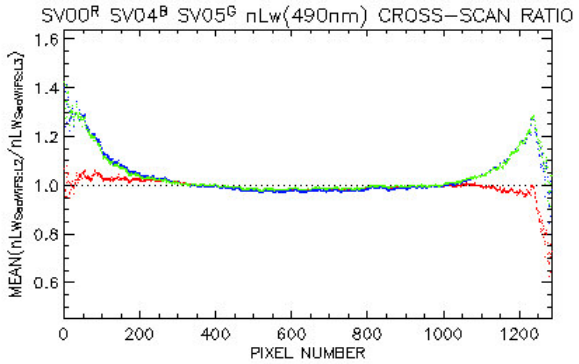
**Fresnel**
**Red**

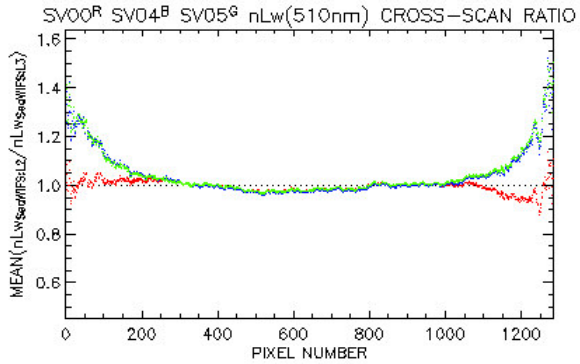
**Morel ℜ**
**Blue**

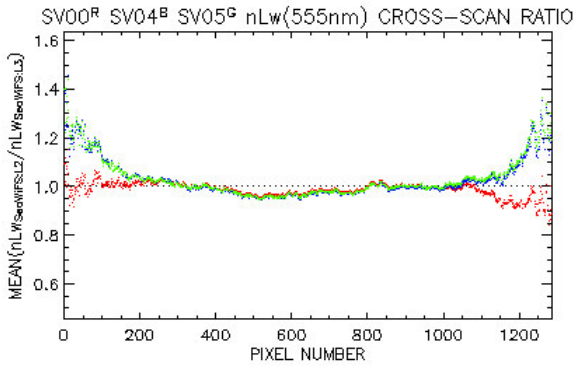
**Morel ℜ + f/Q**
**Green**




**Derived by ratio of SeaWiFS Level-2 nLw with SeaWiFS 7-day Level-3 binned nLw.**

# Effects of BRDF on Scan-Dependence of SeaWiFS nLw

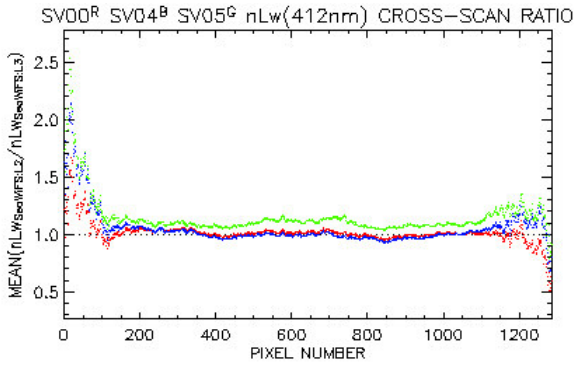
## *moderate chl water ($C > 0.15$ mg/m$^3$)*

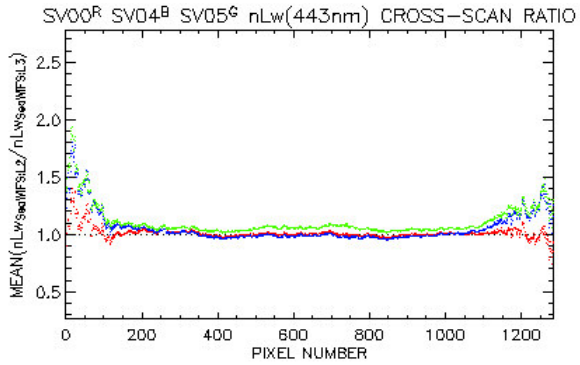
## day 2004 003

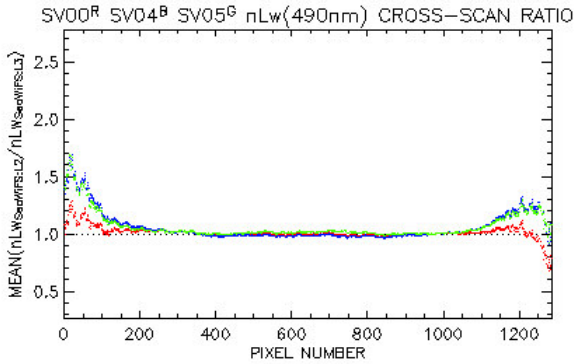
**Fresnel**
**Red**

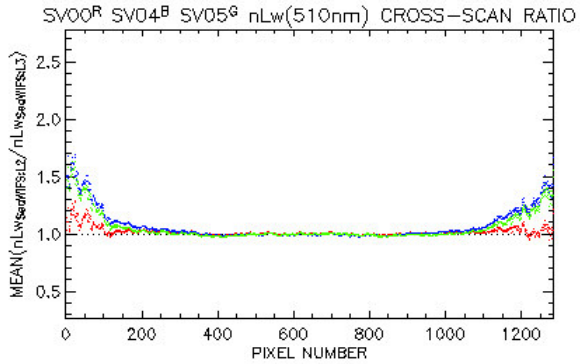
**Morel ℜ**
**Blue**

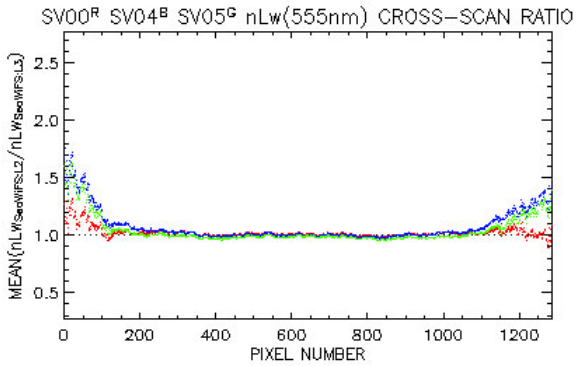
**Morel ℜ + f/Q**
**Green**




**Derived by ratio of SeaWiFS Level-2 nLw with SeaWiFS 7-day Level-3 binned nLw.**

# Effects of BRDF on Scan-Dependence of MODIS/Aqua nLw

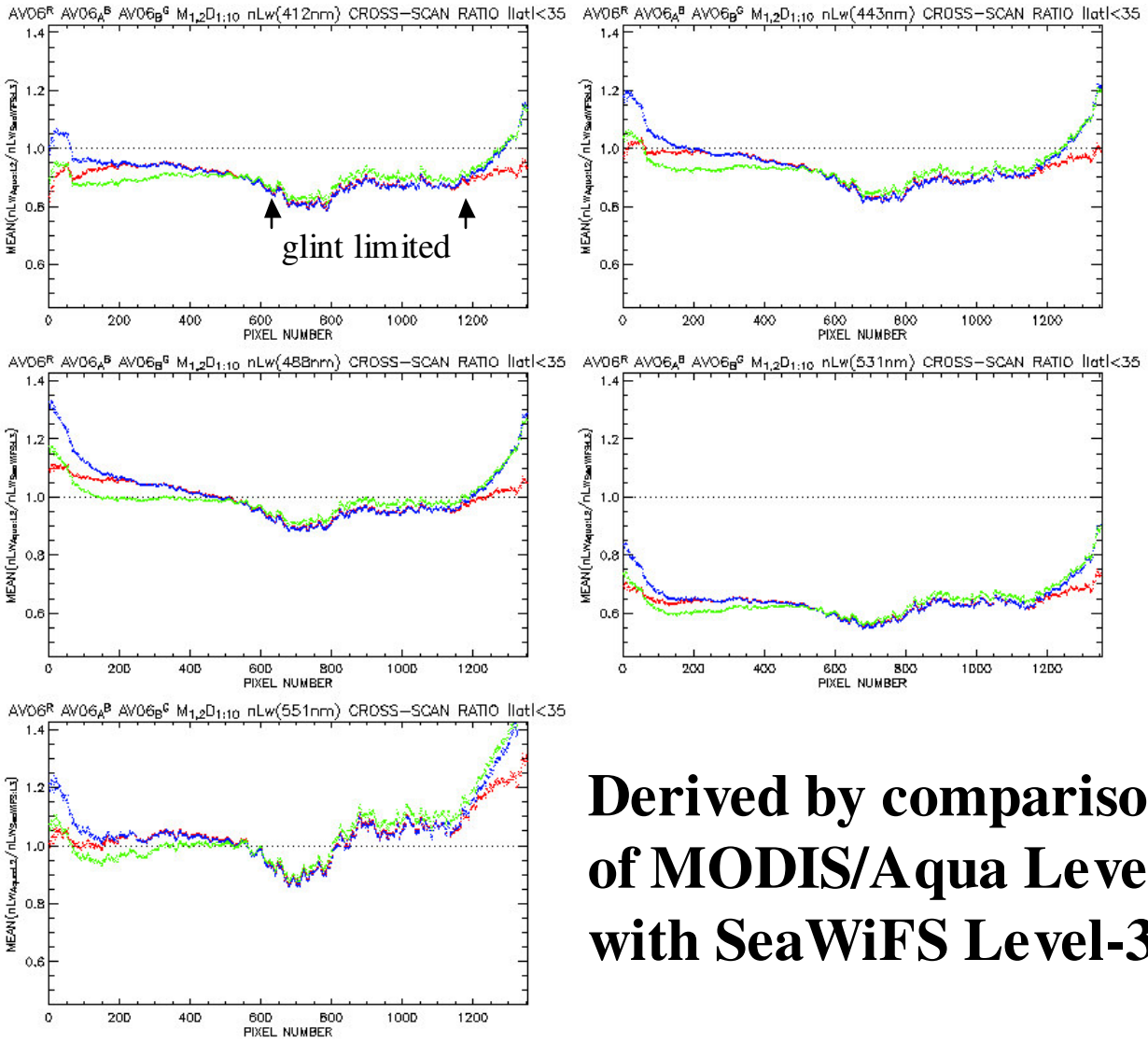
## *low chl water (C < 0.15 mg/m³)*

## day 2004 003

**Fresnel**
**Red**

**Morel ℜ**
**Blue**

**Morel ℜ + f/Q**
**Green**




**Derived by comparison of MODIS/Aqua Level-2 with SeaWiFS Level-3.**

# Effects of BRDF on Scan-Dependence of MODIS/Aqua nLw

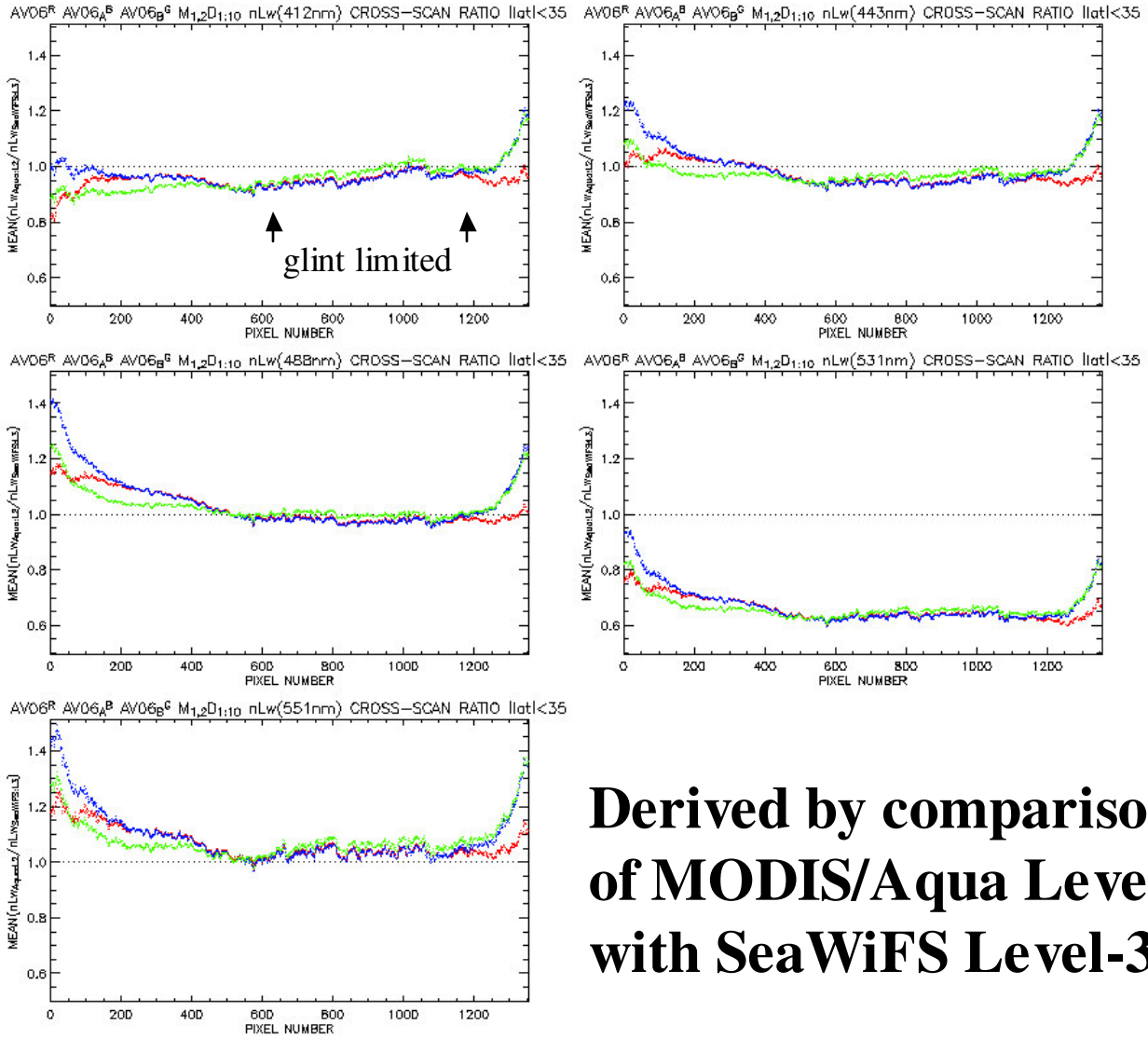
## *low chl water (C < 0.15 mg/m³)*

## day 2002 226

**Fresnel**
**Red**

**Morel ℜ**
**Blue**

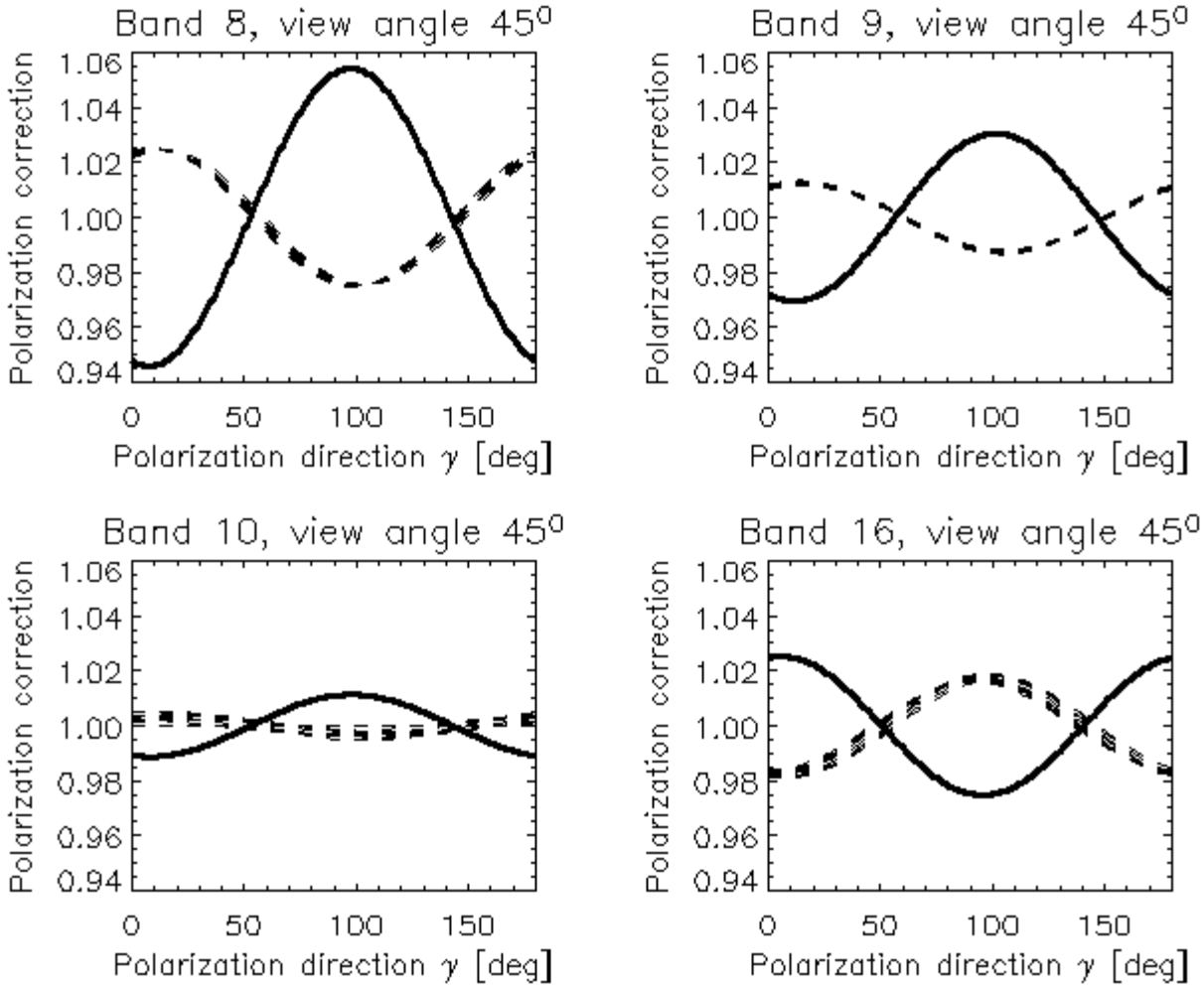
**Morel ℜ + f/Q**
**Green**




**Derived by comparison of MODIS/Aqua Level-2 with SeaWiFS Level-3.**

# Polarization Correction

**Solid line: AT06 polarization correction**
**Dashed line: original polarization correction**

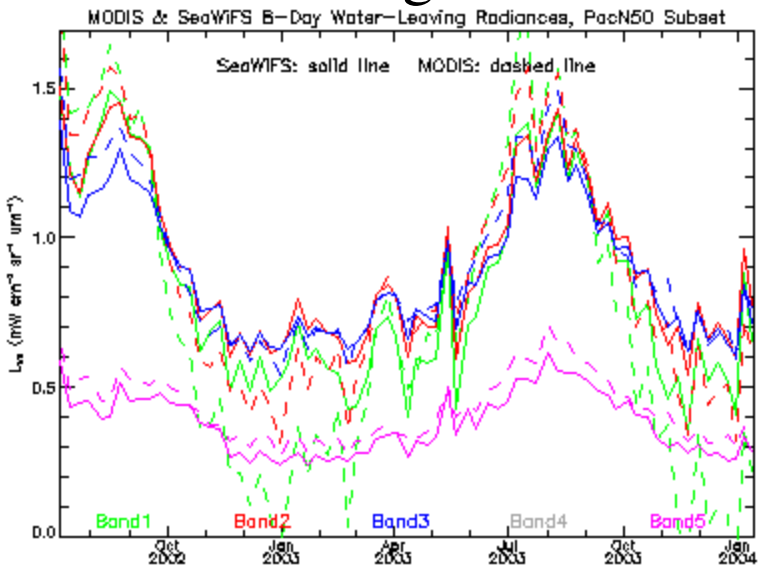


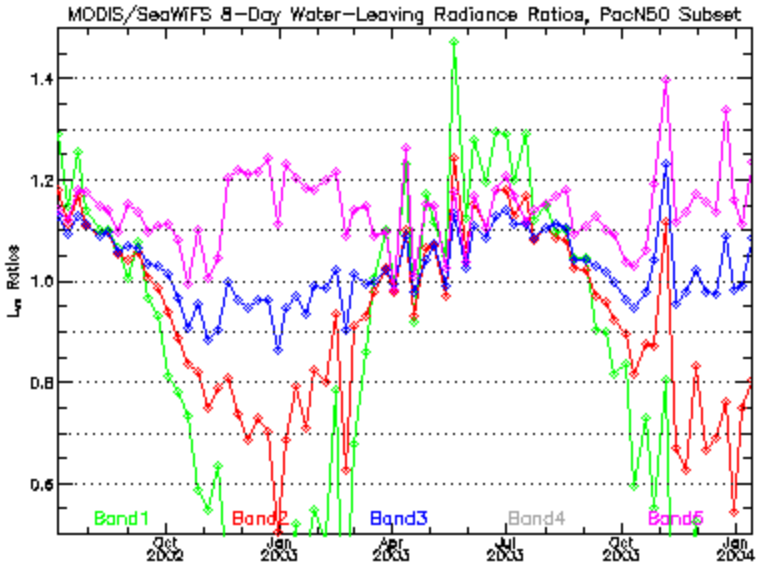
# nLw: MODIS/Aqua vs SeaWiFS

## 50N-40N & 40S-50S, 150W-170W

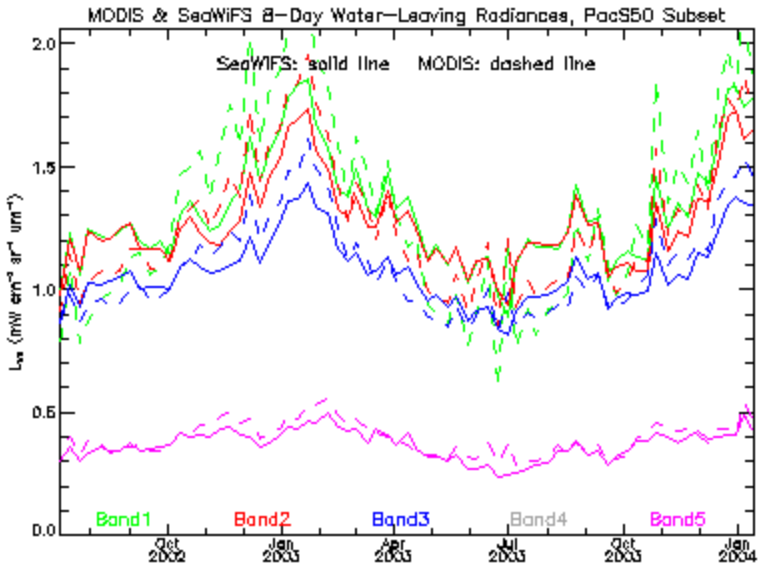
## Original Polarization Correction

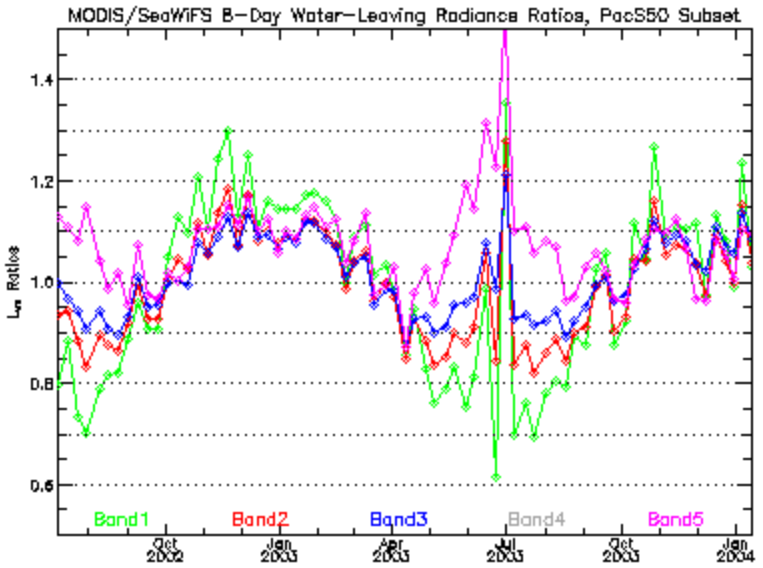
**NH**




**SH**



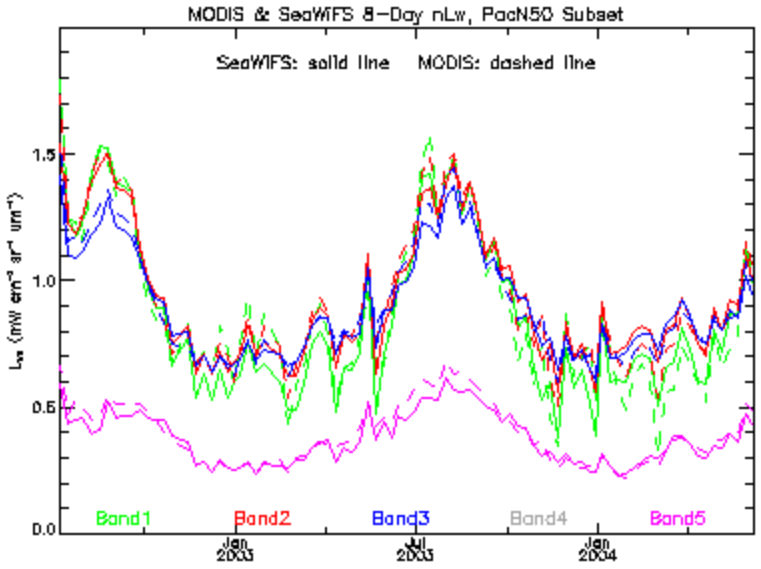



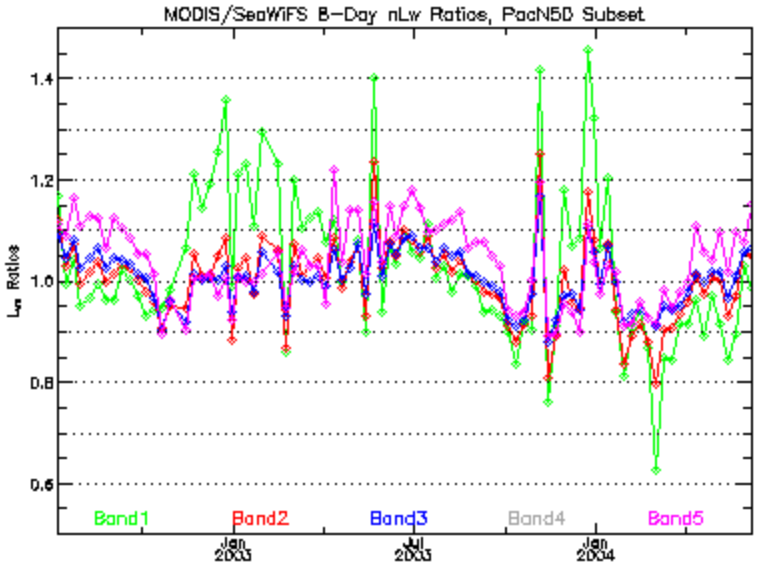
# nLw: MODIS/Aqua vs SeaWiFS

## 50N-40N & 40S-50S, 150W-170W

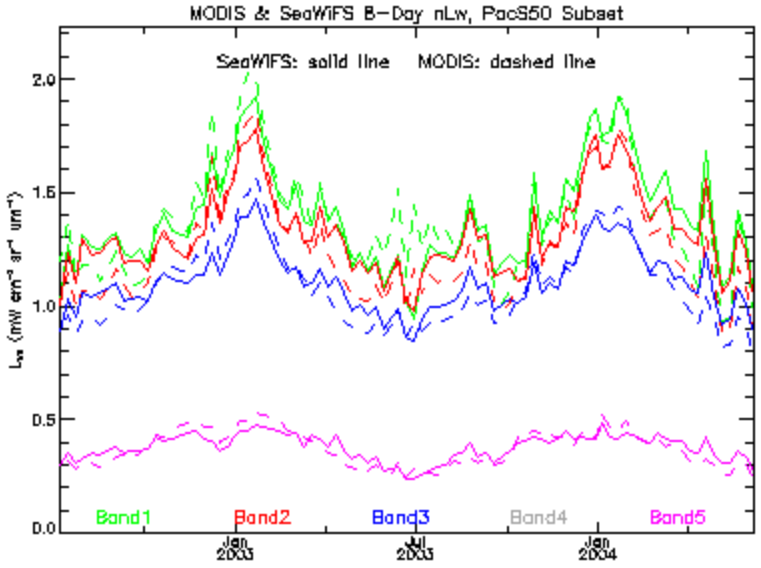
## OCDPS R0 Processing

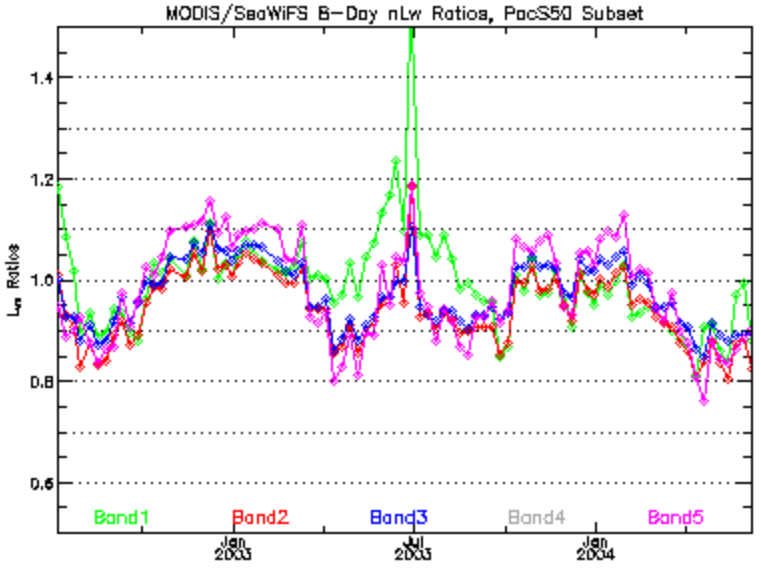
**NH**



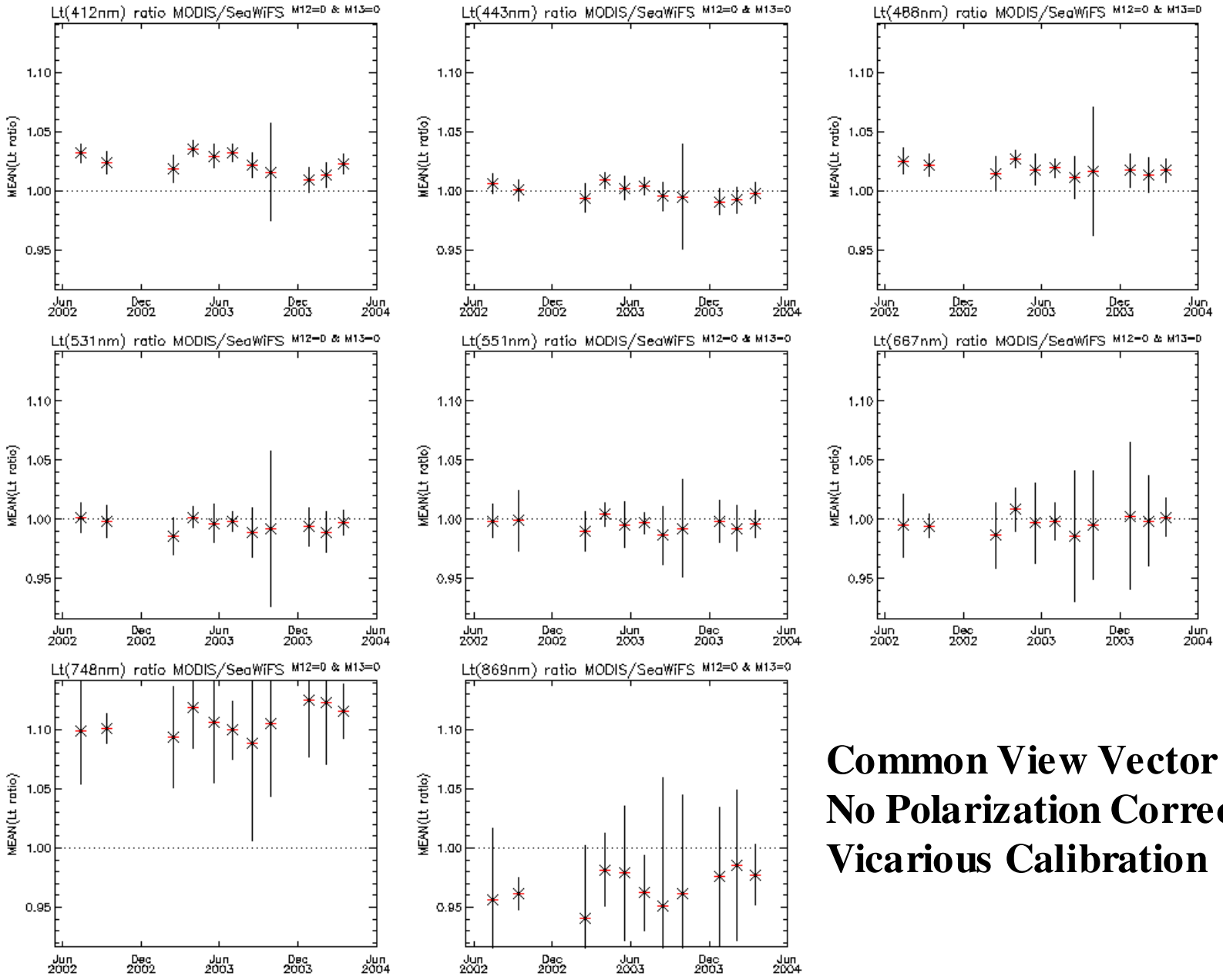

**SH**



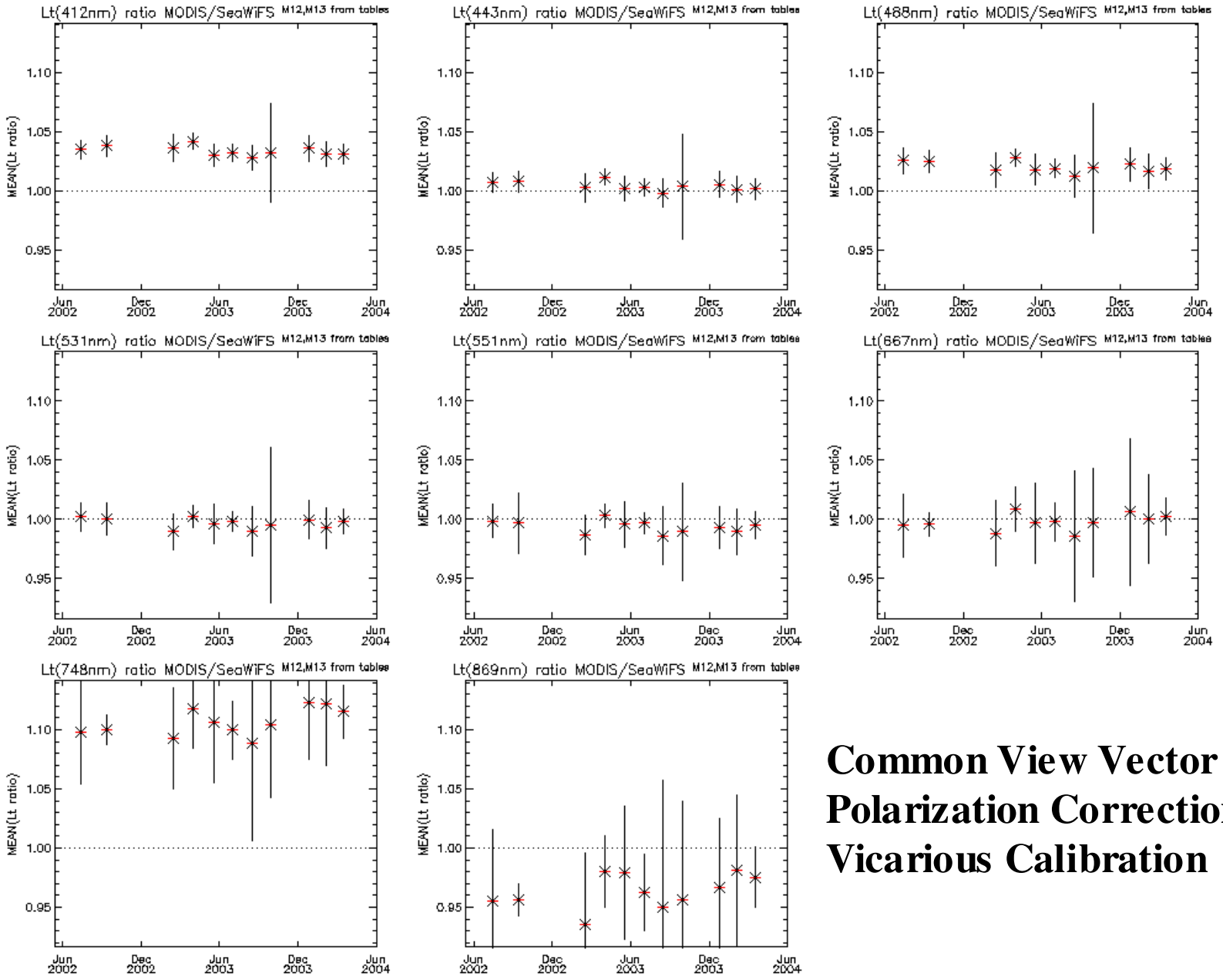
# TOA Radiance Comparisons

# TOA Radiance Comparison: MODIS/Aqua vs SeaWiFS



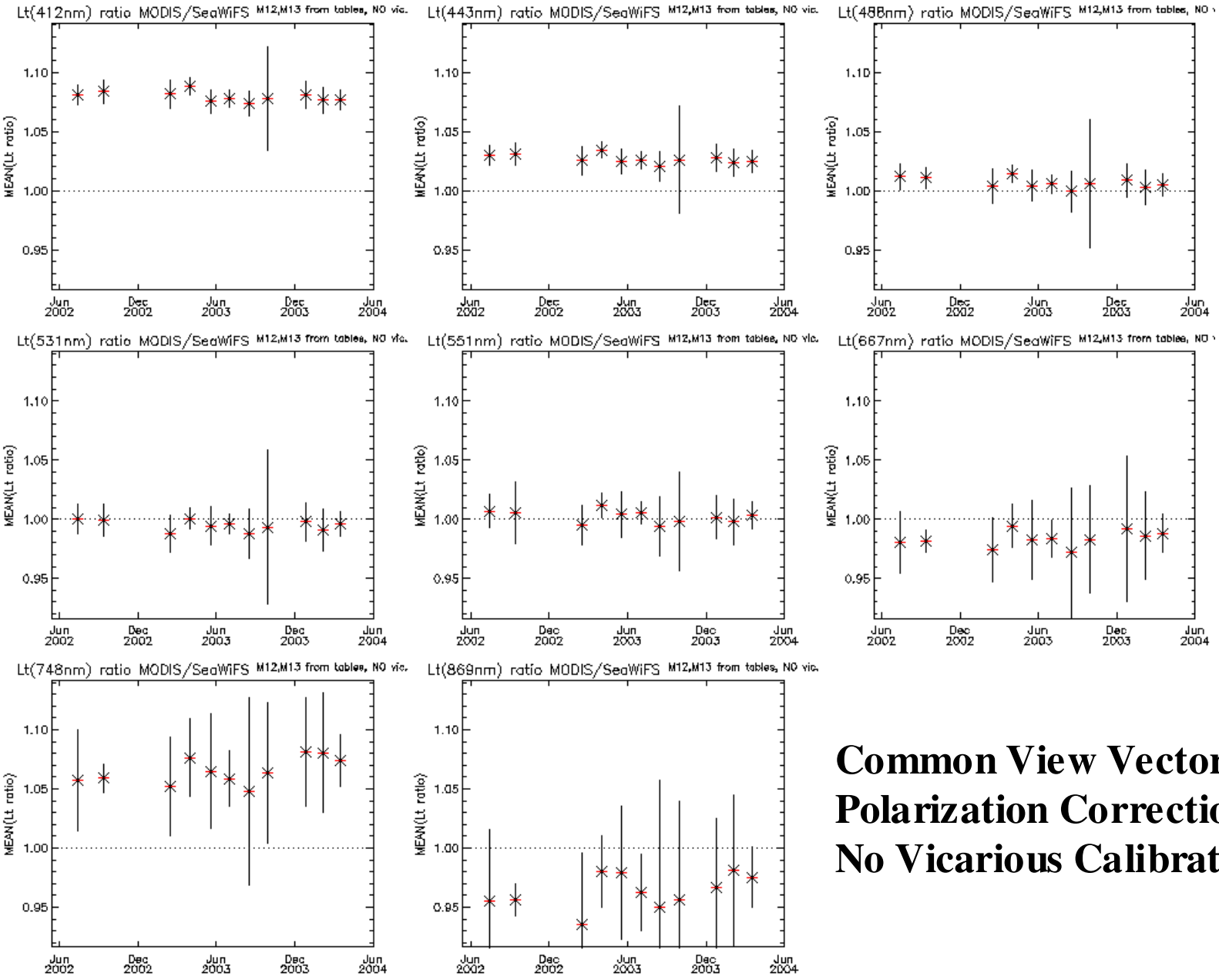

**Common View Vector (1°)**
**No Polarization Correction**
**Vicarious Calibration**

# TOA Radiance Comparison: MODIS/Aqua vs SeaWiFS




**Common View Vector (1º)**
**Polarization Correction**
**Vicarious Calibration**

# TOA Radiance Comparison: MODIS/Aqua vs SeaWiFS

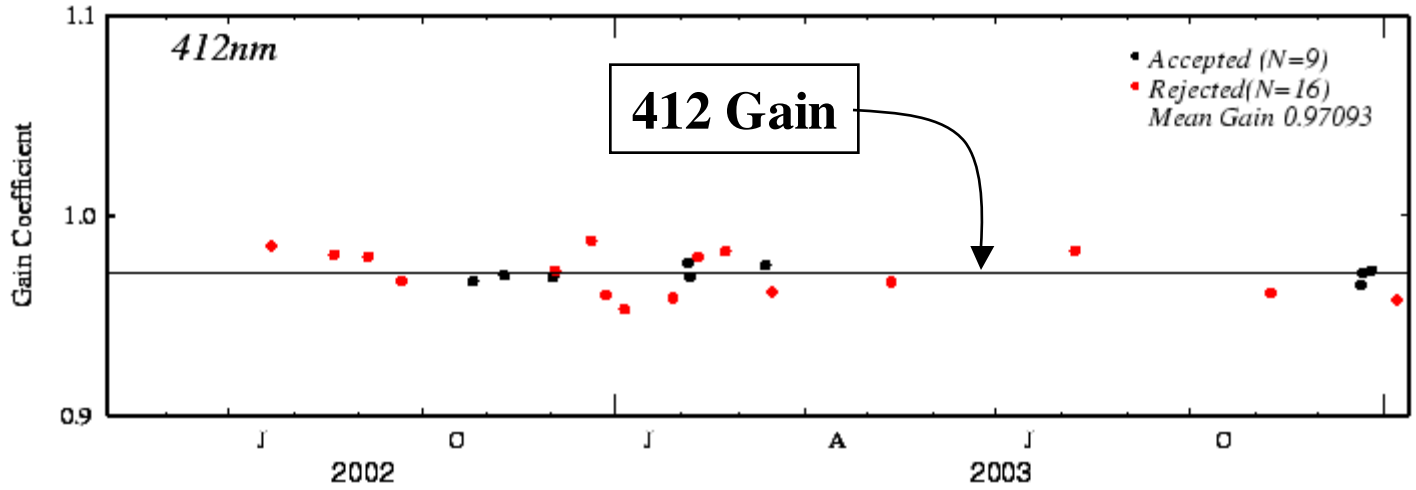



**Common View Vector (1º)**
**Polarization Correction**
**No Vicarious Calibration**

# Vicarious Calibration

# MODIS/Aqua Vicarious Calibration

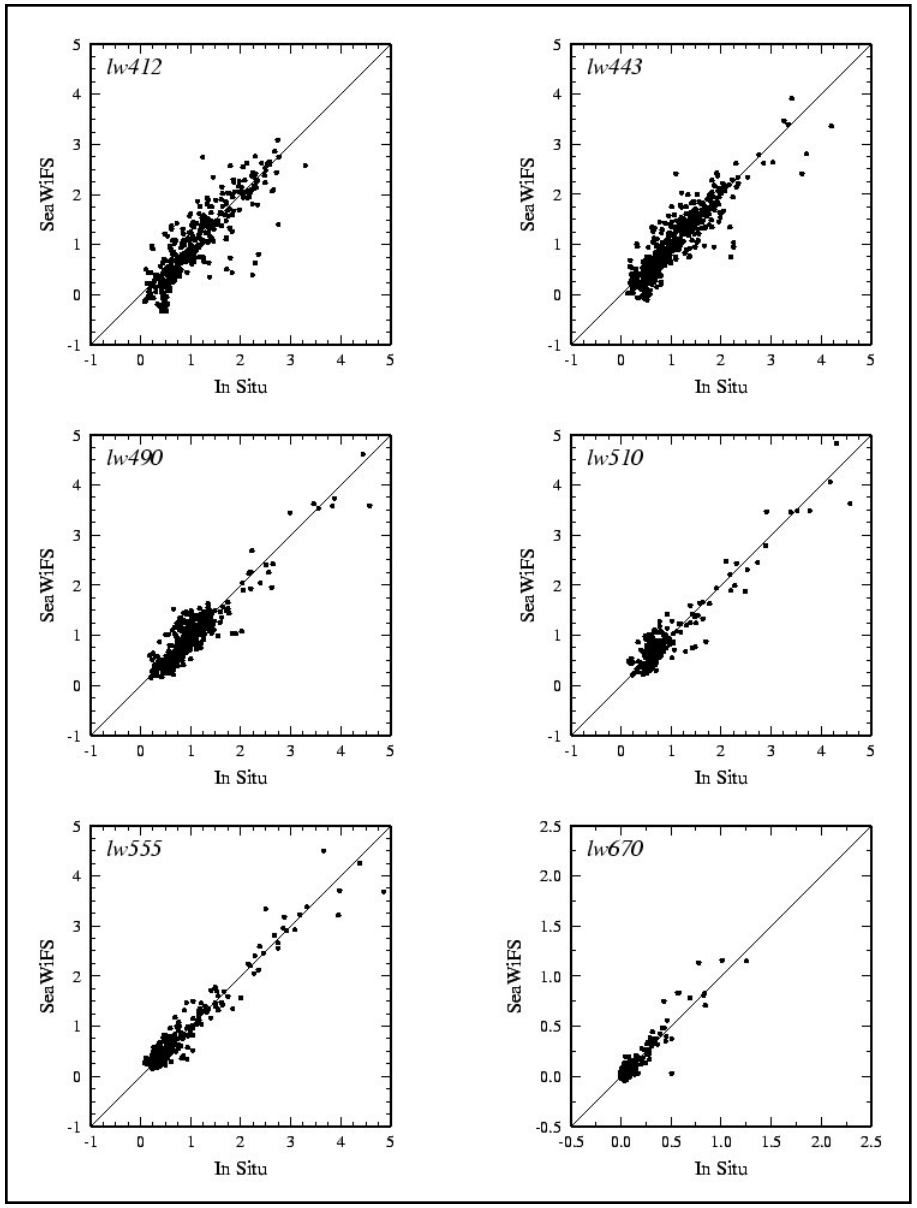
- Same approach used for other sensors (SeaWiFS)
- Fix gain at 869 nm to 1.0
- Set gain at 748 nm to yield assumed aerosol type, on average
- Set visible gains to match MOBY, on average



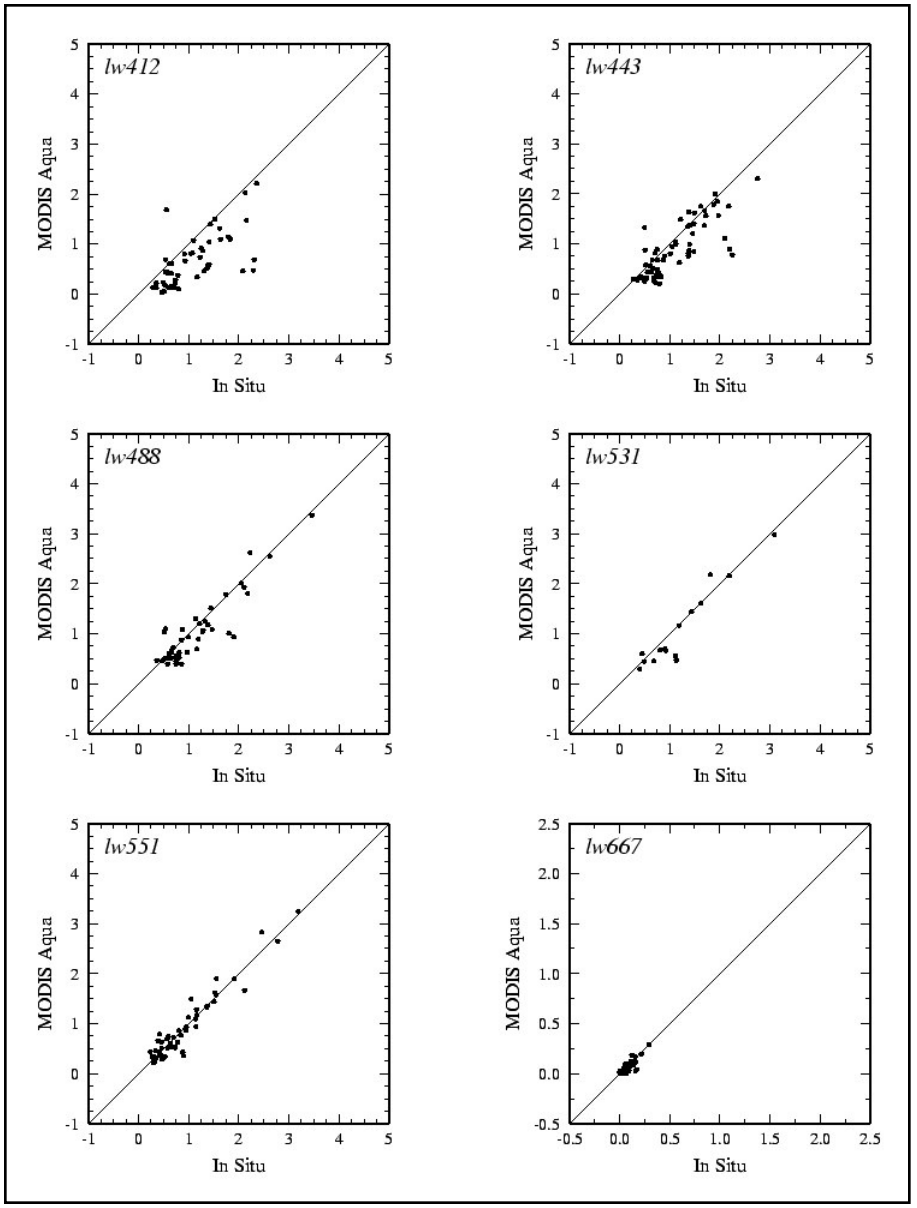

| | 412 | 443 | 488 | 531 | 551 | 667 | 749 | 869 |
|---|---|---|---|---|---|---|---|---|
| Gain | 0.970 | 0.975 | 0.9776 | 0.9852 | 0.9844 | 0.9732 | 0.9789 | 1 |
| Std Dev | 0.003 | 0.005 | 0.0086 | 0.0079 | 0.0077 | 0.0037 | 0 | 0 |

# *In Situ* Validation

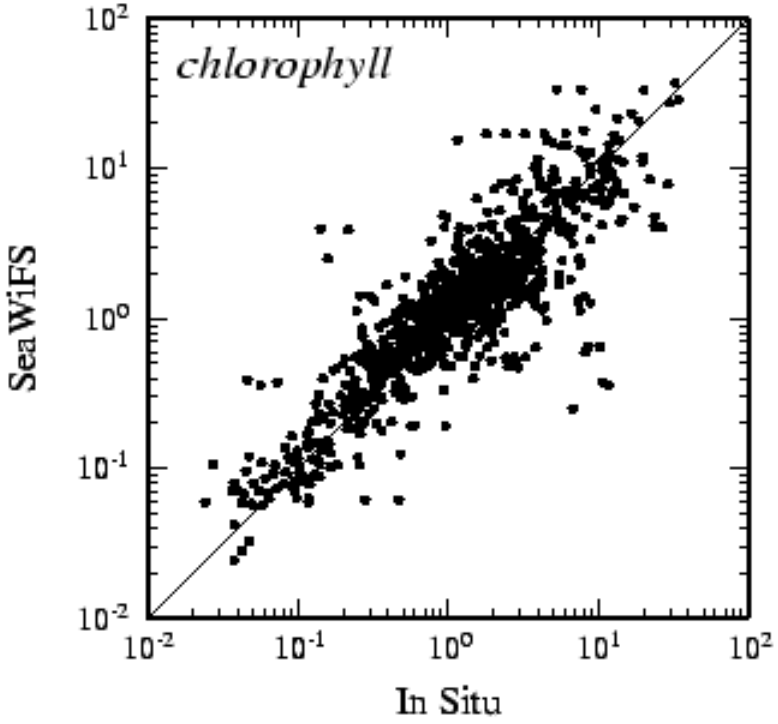
# SeaWiFS Lw
# OCDPS R4



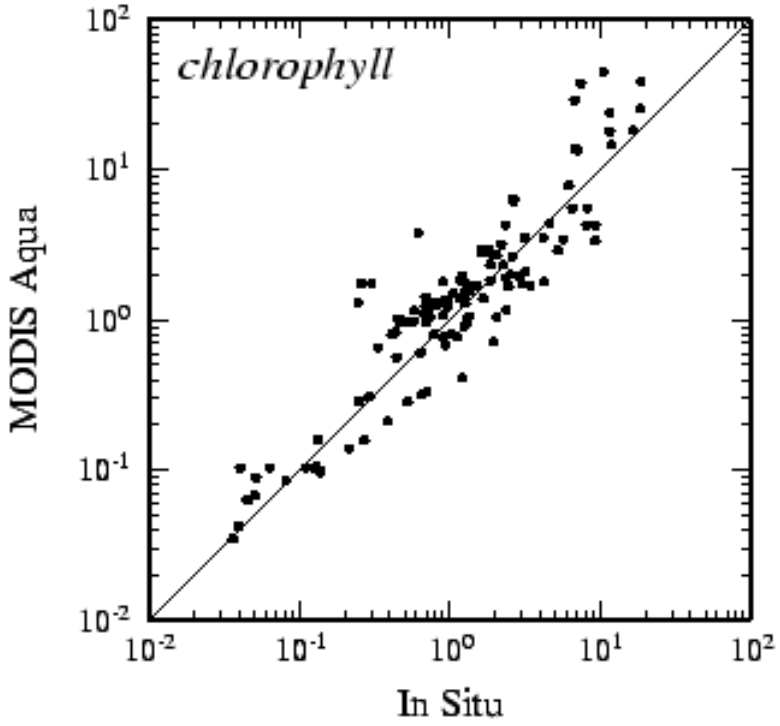

# MODIS/Aqua Lw
# OCDPS R0



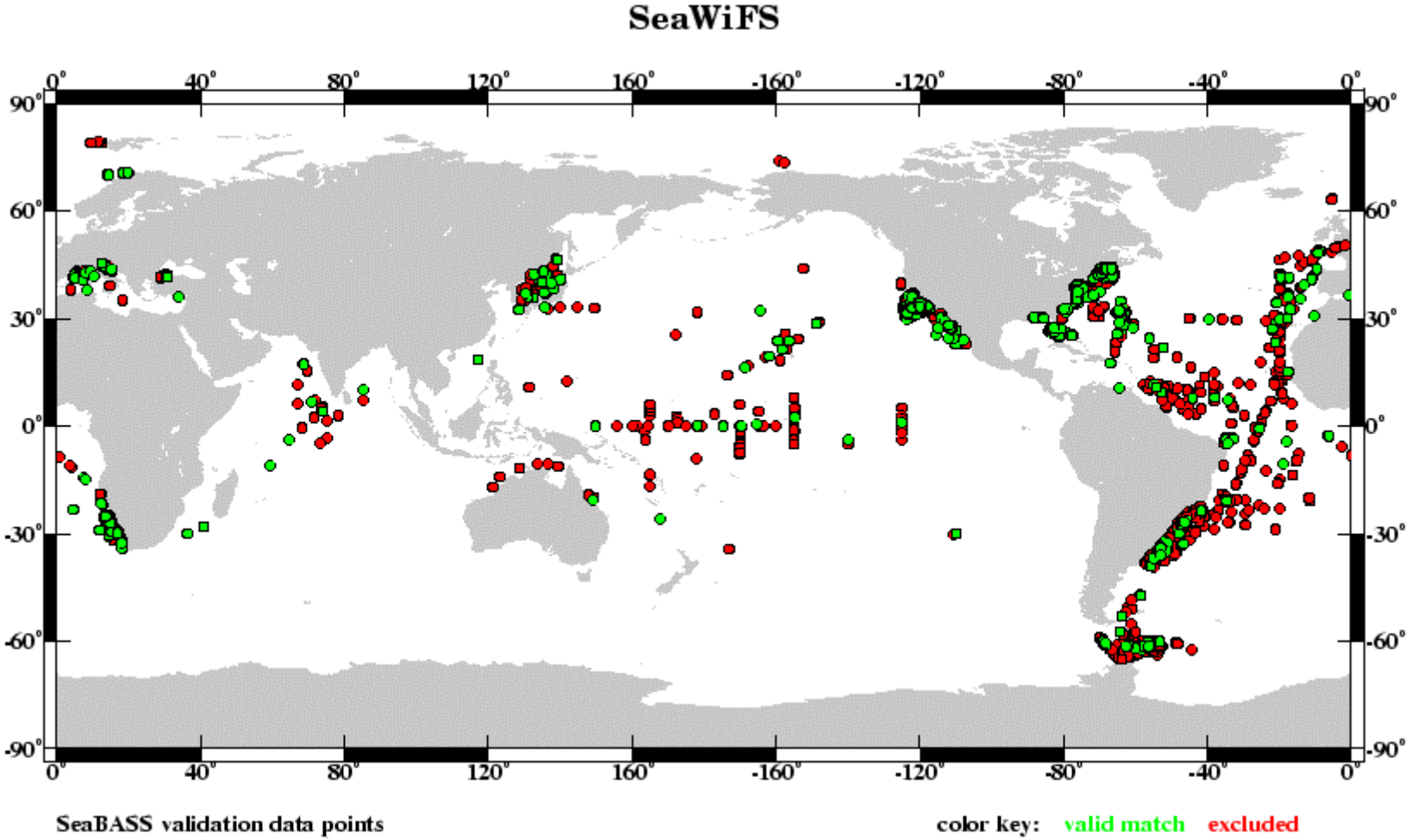
**SeaWiFS**
**OCDPS R4**
**OC4 Chlorophyll**



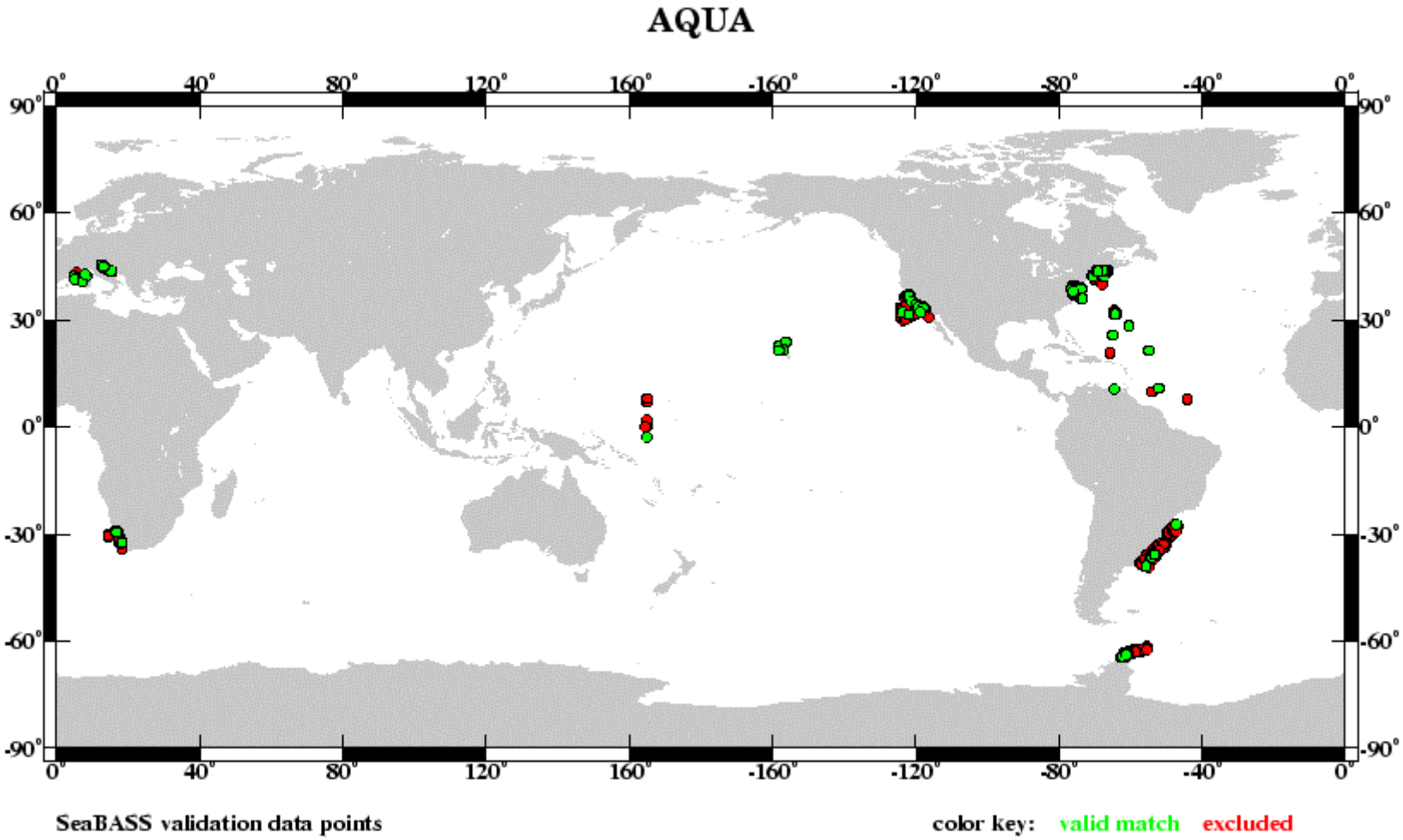

**MODIS/Aqua**
**OCDPS R0**
**OC3 Chlorophyll**



# In Situ Match-up Distribution SeaWiFS



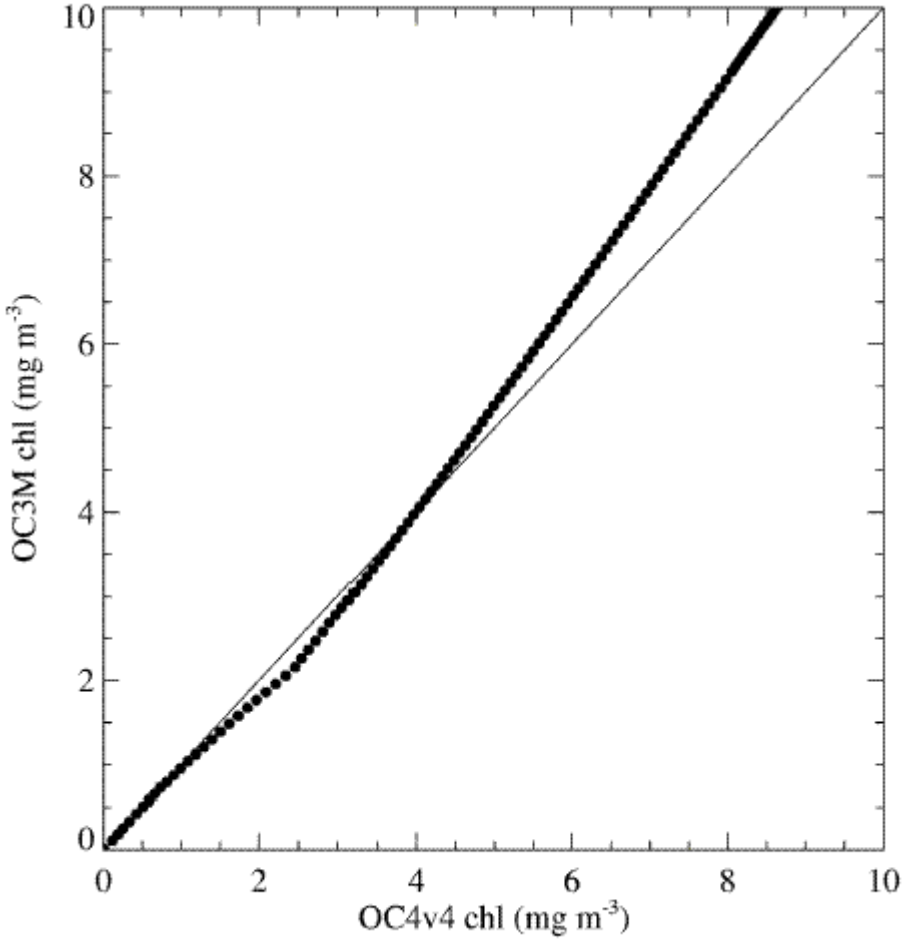
# In Situ Match-up Distribution MODIS/Aqua

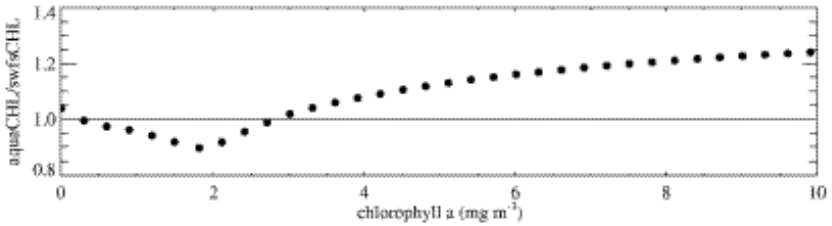


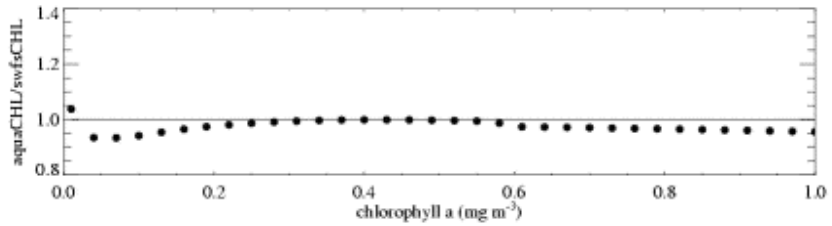
# Chlorophyll Algorithm

# OC3 vs OC4

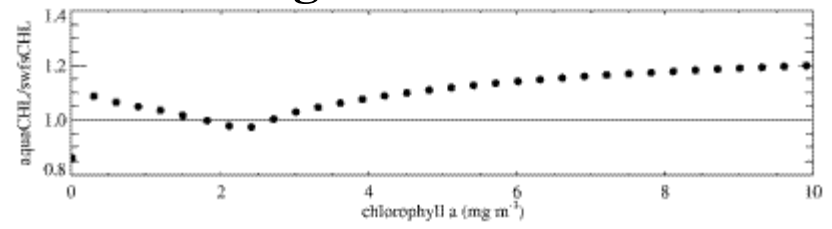
(Simulated Differences Based on Morel and Maritorena 2001)

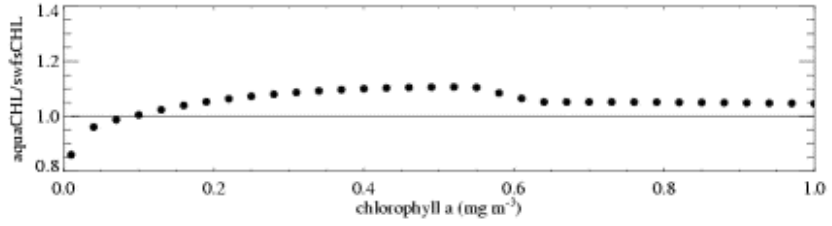



**Including Band-Pass Effects**

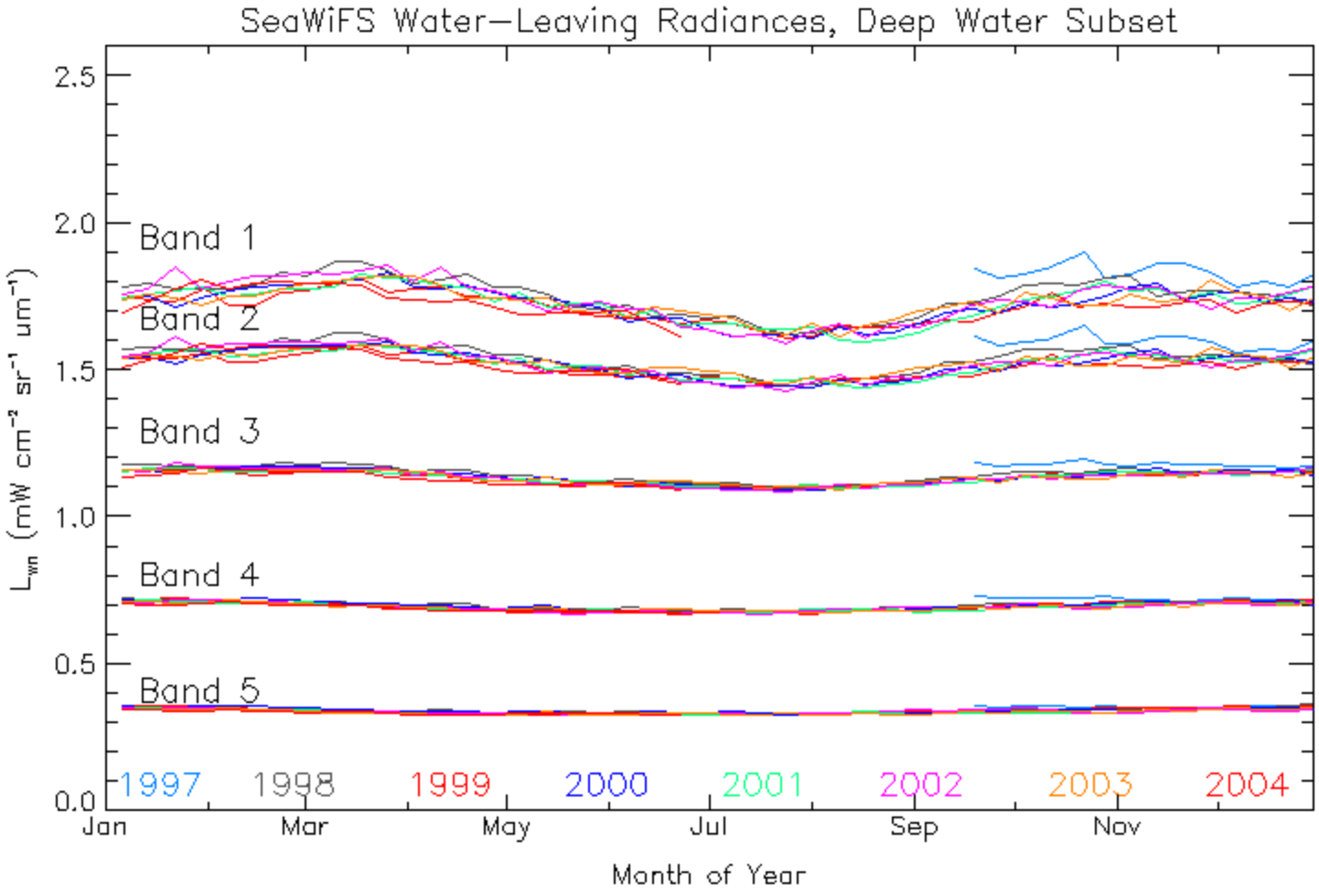


# Misc

# SeaWiFS Annual Repeatability in nLw

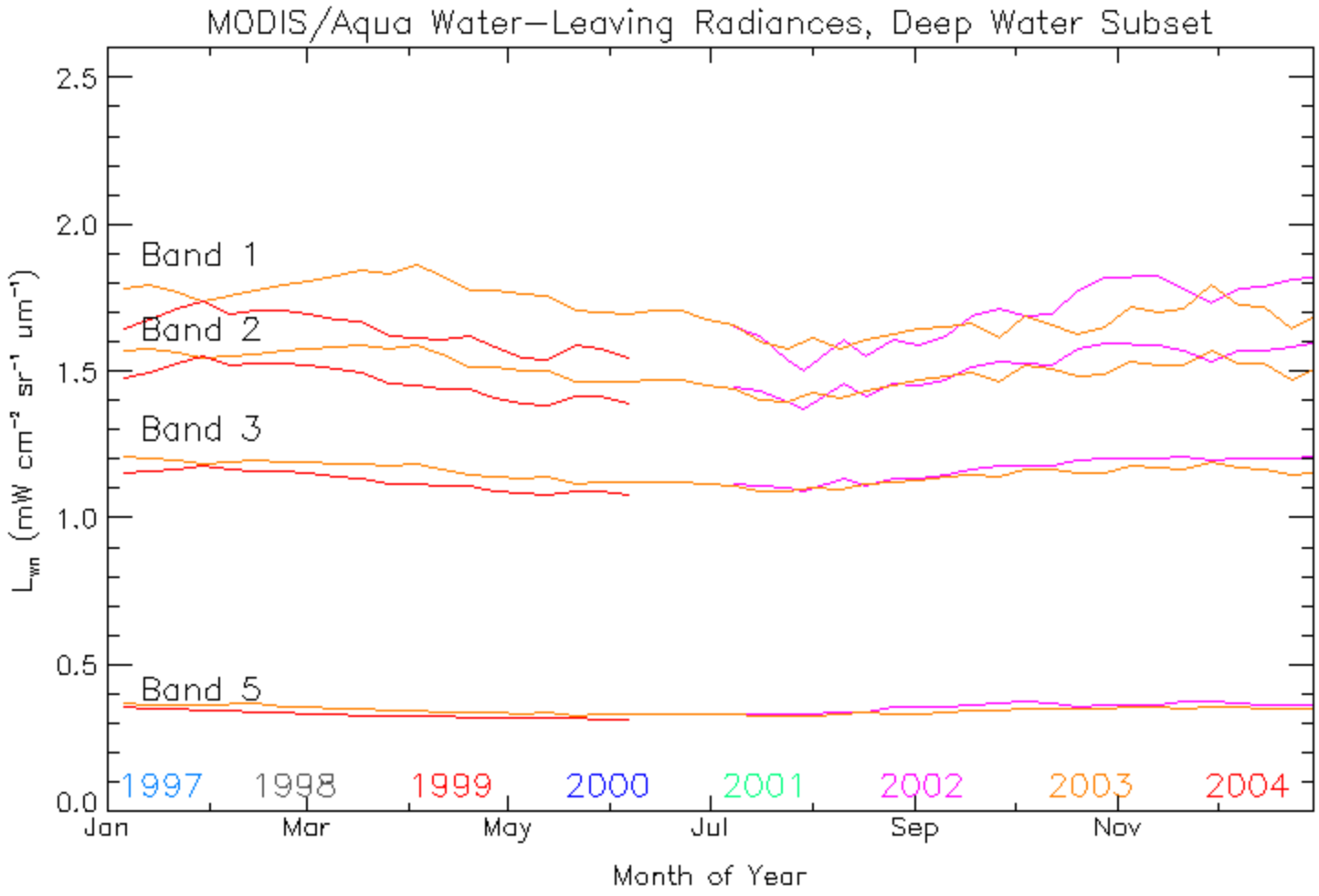
## Deep-Water Subset, 8-Day Bins




SeaWiFS temporal stability is well established.

# MODIS/Aqua Annual Repeatability in nLw

## Deep-Water Subset, 8-Day Bins



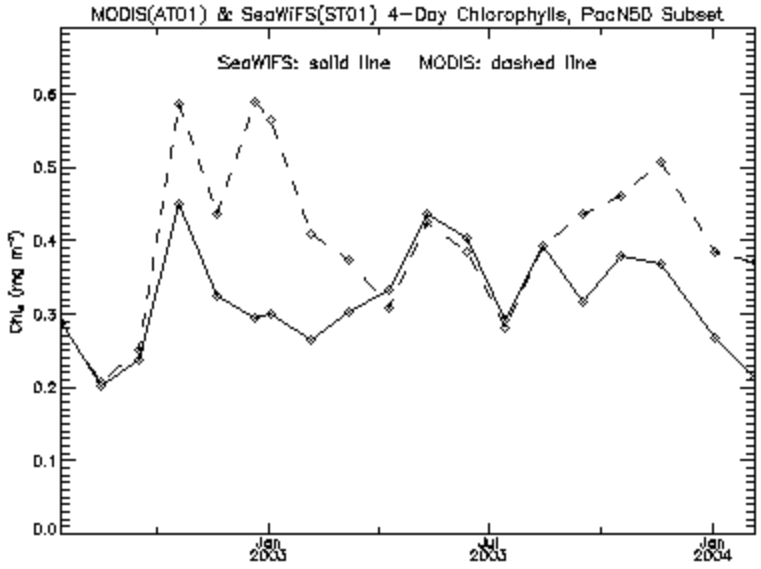

Repeatability for MODIS/Aqua has not yet been demonstrated.

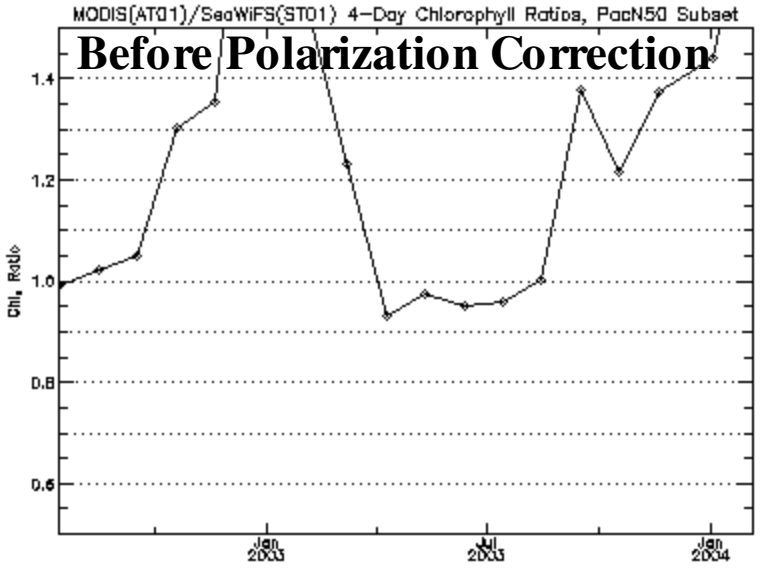
# Chl: MODIS/Aqua vs SeaWiFS

**NH**

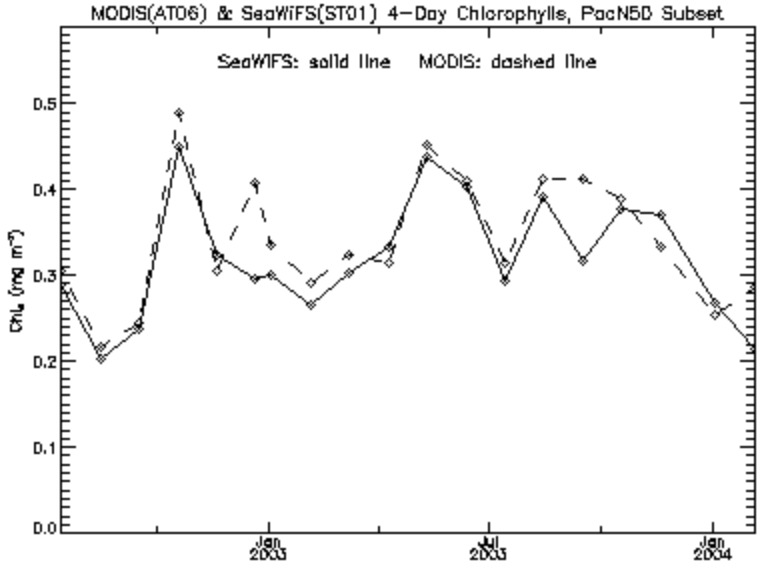
**50N-40N**, 150W-170W

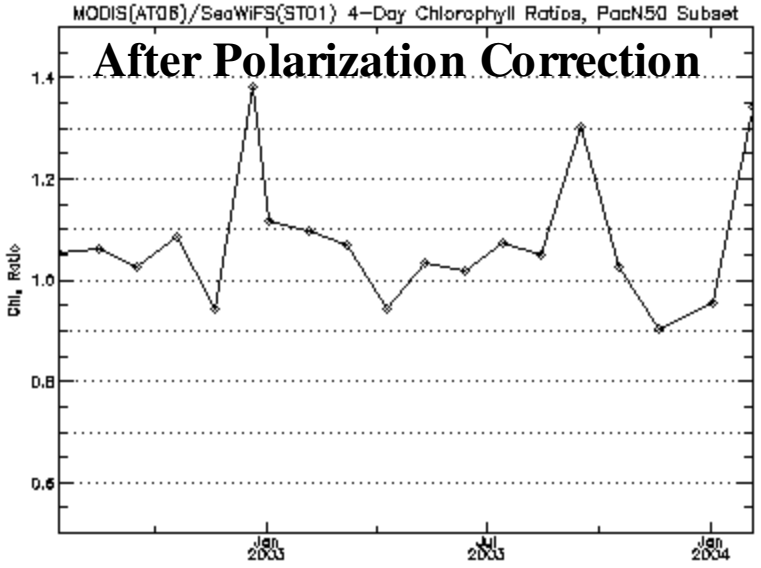
**AT01**




**AT06**



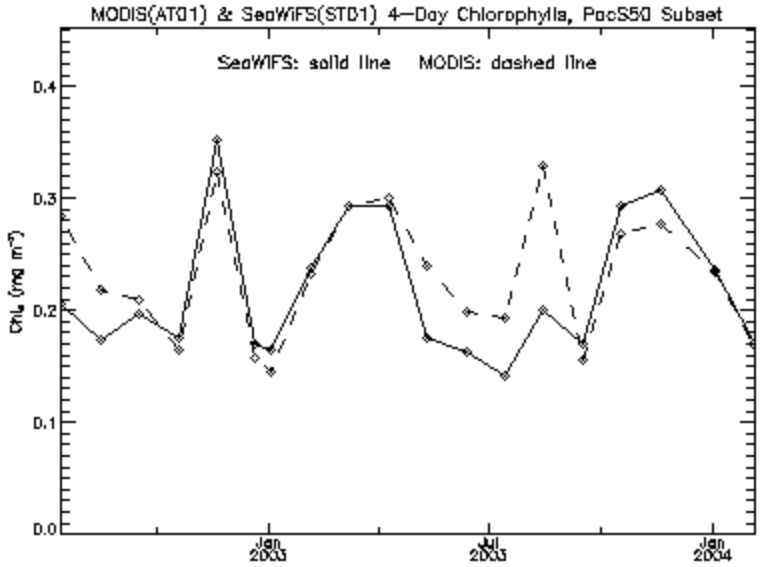



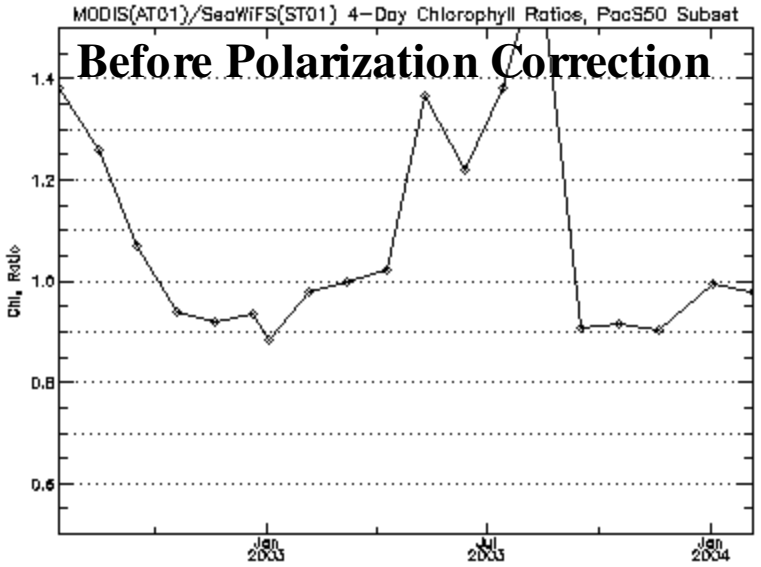
# Chl: MODIS/Aqua vs SeaWiFS

**SH**

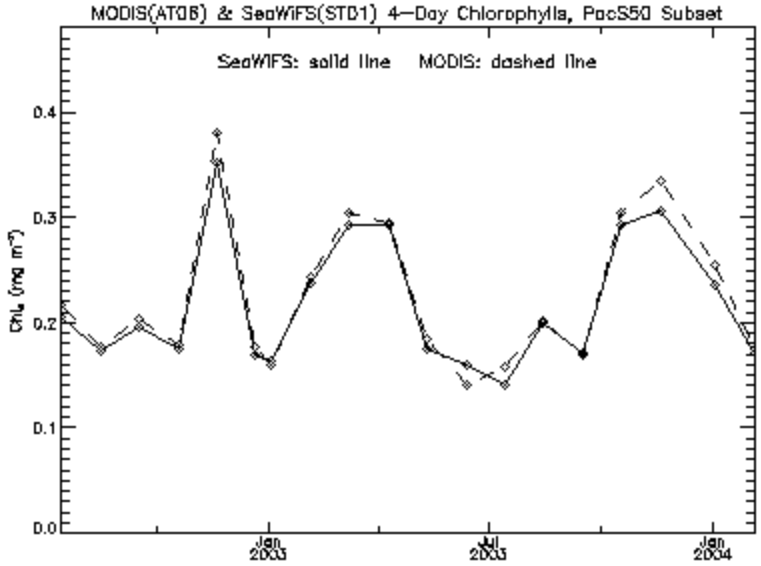
**40S-50S**, 150W-170W

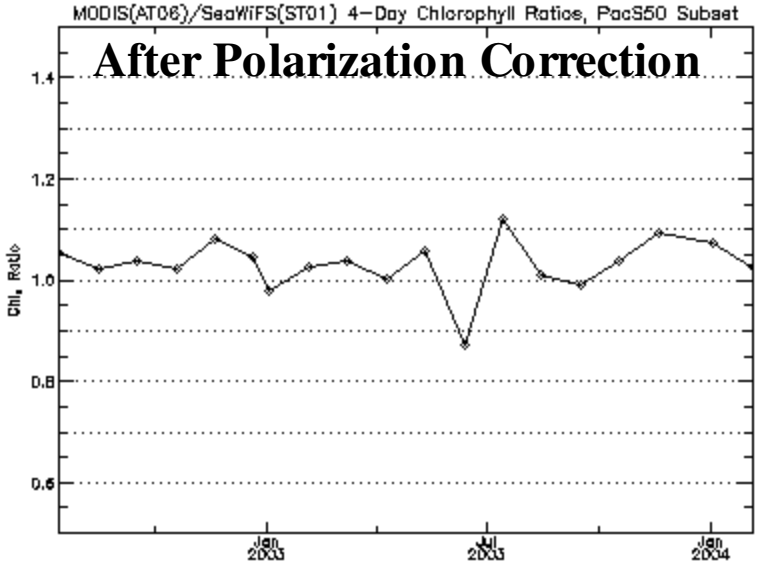
**AT01**




**AT06**



| | | Chlor_a | Chlor_a | nLw_412 | nLw_412 | nLw_443 | nLw_443 | nLw_490 | nLw_490 | nLw_555 | nLw_555 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Sensor | Subset | mean | stdev | mean | stdev | mean | stdev | mean | stdev | mean | stdev |
| SeaWiFS | Clear | 0.077 | 0.0035 | 2.197 | 0.0719 | 1.856 | 0.0493 | 1.249 | 0.0179 | 0.296 | 0.0042 |
| MODIS | Clear | 0.077 | 0.0036 | 2.152 | 0.0926 | 1.833 | 0.0729 | 1.282 | 0.0377 | 0.315 | 0.0123 |
| SeaWiFS | Deep | 0.183 | 0.0125 | 1.736 | 0.0529 | 1.530 | 0.0372 | 1.134 | 0.0186 | 0.334 | 0.0068 |
| MODIS | Deep | 0.189 | 0.0154 | 1.689 | 0.0850 | 1.496 | 0.0599 | 1.148 | 0.0371 | 0.344 | 0.0159 |
| SeaWiFS | Coastal | 1.115 | 0.2043 | 0.778 | 0.0580 | 0.862 | 0.0475 | 0.888 | 0.0420 | 0.474 | 0.0285 |
| MODIS | Coastal | 1.340 | 0.2352 | 0.727 | 0.0837 | 0.848 | 0.0561 | 0.916 | 0.0465 | 0.501 | 0.0299 |